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OF MEDICAL PRACTICE**

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THE
BRITISH ENCYCLOPAEDIA
OF MEDICAL PRACTICE

INCLUDING
MEDICINE SURGERY
OBSTETRICS GYNAECOLOGY
AND OTHER SPECIAL SUBJECTS

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VOLUME SIX

GONORRHOEA TO HYDROTHERAPY

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GONORRHOEA

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Reference may also be made to the following titles:

ARTHRITIS	EPIDIDYMITIS
BALANITIS	FALLOPIAN TUBES DISEASES
CONJUNCTIVA, INJURIES	LEUCORRHOEA
AND DISEASES	RECTUM DISEASES
ENDOSCOPY OF THE	
URINARY TRACT	

1.—DEFINITION

(Synonym.—Clap)

575.] Gonorrhoea is an inflammation of the genital and lower urinary passages causing a purulent discharge, due to infection by *Neisseria gonorrhoeae*, commonly known as the gonococcus. The infection may spread, or be carried, to other parts of the body, such as the mucous membranes of the rectum and conjunctiva, the synovial membranes and fibrous tissues of joints, tendon sheaths and bursae, the iris, and, much more rarely, the endocardium, pericardium, pleura, and meninges.

2.—AETIOLOGY

*Infection of
the male*

In adults infection of the genital and urinary passages is most commonly caused by sexual intercourse. The chances of a male catching gonorrhoea from an infected female are unknown. Probably in the acute and sub-acute stages a woman infects most men with whom she has intercourse, but when the disease has become chronic gonococci appear on the surface only intermittently, being carried there chiefly by the glandular secretions during sexual excitement or at the time of the menstrual period. This would explain some of the cases in which only one of a number of men who have had sexual intercourse with an infected woman on the same day has contracted the disease, and some of those in which a man has been infected by his mistress many months after they have begun living together, although neither has been unfaithful or taken precautions. It does not explain all, because a para-urethral canal opening alongside the meatus can be infected and the urethra escape. Infection by buccal coitus has been reported by Bertoloty and by Mihalovici, although stomatitis was not evident in the infecting persons.

*Infection of
a female*

Probably a female is much more likely to catch gonorrhoea from an infected male, although the fact that in the chronic stages diligent search often fails to discover the gonococcus suggests that males also may be only intermittently contagious.

*Non-sexual
infection*

Urogenital infection of adult females by other means than sexual intercourse can easily occur by contact with contaminated articles, such as irrigator nozzles, towels, and lavatory seats. The idea that men can be infected by similar means is usually scouted as ridiculous, but undoubted cases of this kind have occurred.

*Infection of
infants:
vulvovaginitis*

In female infants and children gonococcal vulvovaginitis is generally caused by contact of the parts with contaminated fingers of attendants, towels, or clinical thermometers. Often in an epidemic of vulvovaginitis in an institution it is very difficult, or even quite impossible, to trace the source of infection, because in a juvenile gonococcus carrier, as in an adult, the results of searching bacteriological tests may repeatedly be

negative. Infection of male children by such means as are responsible for outbreaks of vulvovaginitis in female children is very rare.

Primary infection of the conjunctiva of an infant may occur during birth and is the commonest cause of ophthalmia neonatorum. Apart from this any person may contract gonorrhoeal ophthalmia by contact of the conjunctiva with fingers or articles contaminated with gonorrhoeal discharge. *Conjunctivitis*

Occasionally a direct infection of the skin occurs with abscess formation, as in a case reported by Kingsbury. The mouth is usually resistant, and Frazer and Menton, who have reported on an adult with such an infection, were able to find reports of only about twenty cases.

3.—BACTERIOLOGY

The gonococcus is a diplococcus of which the two elements are hemispherical or kidney-shaped with their flat, or concave, sides facing one another across a space about one-fifth of the size of the whole organism, which is 1μ by 0.6μ . It is morphologically indistinguishable from the meningococcus and *M. catarrhalis*, and in certain conditions streptococci and staphylococci can resemble it very closely. In films of gonorrhoeal discharge taken in the earliest stages of the disease gonococci are seen microscopically in groups of two to twenty or more pairs outside the pus cells or overlying epithelial cells, but when the discharge has become purulent they are mostly intracellular. Usually in a given field of the microscope practically all the gonococci to be seen are enclosed in one or two pus cells, which may be packed with them, while none of the hundreds of other, apparently similar, cells in the same field contain any. *Microscopical appearances*

The organism is Gram-negative, a characteristic of great value in diagnosis if the spreading of the discharge on the slide and its staining by Gram's method are carried out properly. Incorrect technique, especially over-decolorization and the use of a strong counter-stain, can make diplococci that are really Gram-positive appear Gram-negative and difficult to distinguish from gonococci. The film should be thin and even, because ridges and lumps in it are very apt to cause unevenness in the staining process, with over-decolorization. *Staining properties*

A good method of Gram staining is as follows. Fix by passing three times through the flame; cover with 1 per cent solution of methyl violet for one minute; without washing, substitute for the methyl violet a solution containing iodine 1, potassium iodide 2, distilled water 100, for one minute; pour off the iodine solution and mop lightly with filter paper; decolorize by swishing about for not more than thirty seconds in alcohol 96 per cent or stronger; counter-stain for two minutes with 0.2 per cent neutral red solution, containing 0.2 c.c. of 6 per cent glacial acetic acid per 10 c.c. of stain. *Gram's method*

Gonococci have the reputation of being difficult to cultivate, but they grow quite freely on properly made media when the newly sown culture *Cultivation*

is put into the incubator at once. Although somewhat delicate when first planted on artificial media, gonococci remain alive in gonorrhoeal discharges, if kept moist, for a number of days at room temperature or in the refrigerator. Accordingly, when there is no laboratory at hand, it is best to send the specimen sealed in a capillary tube.

Viability

The viability of the gonococcus is important from the point of view of the prevention and treatment of gonorrhoea. It is killed by drying, but in the moist state it can survive prolonged exposure to cold. On the other hand, it is very sensitive to temperatures higher than 37° C. Very important conclusions on this point were arrived at recently by Carpenter, Boak, Mucci, and Warren, who found that 99.9 per cent of the organisms in fifteen strains of various ages were killed by exposure to a temperature of 41° C. (105.8° F.) for four hours or to 41.5–42° C. for two hours. They concluded that the induction of pyrexia was a practicable method of treating gonorrhoea, and this has now been done by a number of workers with brilliant results (see p. 18).

Gonococci appear to be killed by relatively weak concentrations of various antiseptics.

4.—PATHOLOGY

The survival of such a delicate organism as the gonococcus since the earliest historical times, and the fact that the determination of cure of gonorrhoea is one of the most anxious and difficult tasks in medicine, are due to the ability of the germ to invade the glands and crypts and the deeper layers of the mucous membranes, where it is safe from attack by locally applied remedies.

Anatomical incidence

The membranes and glands chiefly susceptible to attack are those lined with cylindrical and stratified cuboidal epithelium—the male urethra behind the fossa navicularis, Skene's tubules and the glands opening into the female urethra, the uterus and Fallopian tubes, the greater vestibular (Bartholin's) ducts and glands, the rectum, and the conjunctiva. The fossa navicularis of the male urethra, being lined with squamous epithelium, is generally resistant, and the same applies to the adult vagina, except perhaps the posterior fornix. On the other hand, the juvenile vagina is very susceptible to infection.

Invasion and reaction

In the mucous membrane and the glands opening thereon the gonococci penetrate between the epithelial cells, which are freely shed, deeply into submucous tissues; for example, in the male as far as the trabeculae of the corpus spongiosum. The reaction by the tissues is usually a violent outpouring of leucocytes and plasma, which usually in the long run clears out the infection. The affected glands and crypts become stuffed and their openings blocked with inflammatory products, and there is considerable perifollicular reaction. This may go on to abscess formation and end in the production of more or less fibrous tissue, which by contraction may narrow the affected canal.

Later effects

After a few weeks the tissue reaction usually abates considerably in

violence and gradually dies out altogether with the final exclusion of the gonococci. On the other hand, in an important proportion of cases there are left below the surface foci of infection which communicate with the surface only imperfectly or intermittently. It is these foci which are responsible for the comparative intractability of gonorrhoea. In some men and an important proportion of women the tissue reaction is by no means violent. In fact sometimes a woman is found to be harbouring gonococci in the cervical canal without showing any sign of local inflammation. The importance of the tissue reaction is shown by the fact that in men who react only mildly the disease seems usually to run a more protracted course, whereas in those with particularly violent inflammation of the parts the attack often clears up quickly and completely.

The gonococcus is believed by most workers to spread to other parts of the urogenital canal and its adnexa along the surface, but Kenneth Walker has produced evidence of spread along lymphatics. In the male the disease spreads very frequently into the prostatic follicles and seminal vesicles, from which it may invade one or both epididymes. In the female similarly the Fallopian tubes are often invaded, with consequent obstruction of the affected tube and inflammation of neighbouring pelvic tissues of various degrees of severity. *Methods of spread*

Invasion of the blood-stream probably occurs far more often than metastatic complications. Apart from the evidence of blood culture it would be difficult to explain those cases in which a joint, a tendon sheath, or a bursa which has been injured or overworked has been the only one in which a metastatic complication has occurred. *Metastases*

Of all the parts that are invaded via the blood-stream the joints, tendon sheaths, and bursae are much the most often affected and after them the iris and conjunctiva. Gonococcal ulcerative endocarditis is rare, and isolated cases only have been reported of pleurisy, pericarditis, neuritis, meningitis, and encephalitis. Gonococcal osteomyelitis and osteoperiostitis have been reported by Finger, Ghon and Schlagenhauser, Bardenwerper, and others. Nephritis and pyelonephritis may be the result of ascending infection, as in the case recorded by Dourmashkin and Cohen, or of infection through the blood-stream, as may have been the explanation of a case reported by Bianchetti. Purpura has been traced to gonococcal infection by finding the gonococcus in the skin lesion and by blood culture. Two cases of gonococcal septicaemia reported by Tebbutt and one by Chevallier and his colleagues were proved by blood culture; all had purpura and proved fatal, but metastases were not found. Two others, reported by Wheeler and Cornell and by Garlock, were cured by operative removal of the genital foci. There does not appear to be any record of isolation of gonococci in the skin affection called keratoderma blennorrhagica, which sometimes complicates gonococcal arthritis. Subcutaneous and subfascial abscesses containing gonococci which must have arrived by the blood have been reported by Randall and Orr and others. Randall and Orr quoted

reports of metastatic gonococcal subcutaneous abscesses by Kirmse, Dufour, and other workers. Robertson reported a case of metastatic gonococcal abscess under the extensor muscles of the thigh and Oxley one of gonococcal mastitis.

Antibodies

Apart from the local defensive reaction, after the infection has lasted a few weeks, the blood-serum generally shows evidence of the development of antigenococcal substances in the form of complement-fixation and various flocculation reactions. The immunity which is developed in the course of an attack of gonorrhoea seems, however, to be only partial and, although very useful in helping the patient to rid himself of the resident gonococci, does not seem to protect against gonococci introduced from without.

5.—GONORRHOEA IN MALES

(1)—Clinical Picture

Incubation

576.] The incubation period of gonorrhoea is usually about three days, but may be as long as three weeks or more. Prolongation of the incubation may possibly be due to high resistance on the part of the patient, but more probably to smallness of the dose of infecting organisms. Thus the incubation period can be particularly long when infection occurs in spite of a condom having been worn, and it is not difficult to imagine that in such a case only a very small amount of the woman's discharge was accidentally transferred to the man's urethral meatus during removal of the condom.

Symptoms

The first symptoms are usually a very slight feeling of irritation at the meatus and a little mucoid discharge, in which the gonococci may be mostly extracellular and there are large numbers of epithelial cells. Skilled treatment at this stage would often abort the disease, but the patient very rarely seeks advice until at least a day later, when the gonococci have become well established and the discharge is more abundant and creamy. The symptoms rapidly increase in severity and by the end of the first week the picture is one of severe urethritis. The meatus is usually reddened and oedematous, and there is often more or less discomfort on urination; owing to abundance of the discharge the urine is hazy or turbid. At night the patient's sleep may be disturbed by painful erections; these may be straightforward, or the penis may be more or less distorted in them (chordee), being curved downwards or to one side. On the other hand, in very many cases there is practically no discomfort, so that the patient who has heard much about the symptoms of gonorrhoea from his friends may think that his urethral discharge must be due to some other cause.

Chordee

(2)—Course

Usually the symptoms continue unabated until the end of the third week and then in favourable cases begin to decline and may disappear

completely by the end of the fifth or sixth week after a period during which discharge does not appear but the urine, although it has gradually become clear, still contains heavy purulent threads. In a large proportion of cases, however, the attack does not clear up so satisfactorily and quickly. In some, even though the infection does not spread to the posterior (membranous and prostatic) urethra, it continues in a sub-acute or chronic form for many weeks. During this time there may be only a very slight discharge to be seen at the meatus and only in the morning before the first urination, or there may not seem to be any discharge, but the urine, although clear, contains large purulent threads which quickly sink.

In most cases during the third or fourth week the disease spreads to the posterior urethra and thus gains access to the prostatic gland and the ejaculatory ducts and seminal vesicles, whence it may extend to the ductus (vas) deferens and epididymis on one or both sides. The local complications resulting from this extension of the disease will be discussed later (see p. 10). The onset of posterior urethritis may be marked by urgent dysuria, with great frequency of micturition and perhaps the passage of a few drops of blood when the urinary stream is cut off. On the other hand, the fact that the disease has spread to the posterior urethra is very often discovered only when either some complication, such as prostatitis or epididymitis, shows that the infection must have passed beyond the triangular ligament, or large numbers of pus cells are found in the secretions of the posterior urethra or the prostate and seminal vesicles.

The common method of ascertaining whether or not the posterior urethra is infected is to apply Thompson's two-glass test. The patient passes an ounce or two of urine into one glass and the balance into the other. If both specimens remain turbid or hazy after the addition of acetic acid to dissolve phosphates, posterior urethritis is diagnosed; if only the first specimen is turbid or hazy, the disease is supposed to be still confined to the anterior urethra. The chief defect of the test is that it does not disclose posterior urethritis until this is so far advanced that the discharge is abundant enough to mix with the urine in the bladder.

A much better method is to make the patient hold his urine for at least four hours and then to wash out the anterior urethra thoroughly before taking the specimens of urine. Threads and pus cells in the urine can then fairly safely be attributed to posterior urethritis. Such a method of examination may not always be practicable or necessary in the acute stages of the disease but is essential in chronic or relapsing cases when the discharge is slight and it is necessary to ascertain with certainty whether or not it is being formed in the anterior or the posterior urethra.

Invasion of the prostate and seminal vesicles seems to be the chief method by which the gonococcus gains access to the blood-stream and through this invades joints, tendon sheaths, bursae, and other parts of the body. It is easy thus to understand how invasion of the posterior

*Posterior
urethritis*

*Two-glass
test*

*A better
method*

Prostatitis

urethra opens up possibilities of such an extension of the disease as may prolong it for many months. Eventually the disease may die out quite uneventfully in a few weeks after the onset of the posterior urethritis, or it may drag on for many weeks, months, or even years while the patient has no more than a slight morning gleet or repeatedly relapses very quickly after any suspension of treatment. Commonly, however, in the cases in which the urethritis has persisted for years the cause is found to be a secondary infection, the gonococcal having disappeared.

This general description of the course of gonorrhoea in the male shows how much the course of the disease may vary and how unwise it would be to yield to the patient's usual request, often repeated, to tell him the probable duration of his attack.

*Factors
influencing
course*

The factors which seem most to influence the course of gonorrhoea are as follows. Skilled local treatment materially shortens the average duration of the disease. From time to time the truth of this is questioned, so far as acute gonorrhoea is concerned. It is pointed out that no chemical antiseptic in a safe strength can destroy gonococci in the mucous membrane, and it is argued that local treatment must therefore not only be useless but may cause local complications. This contention is not supported by the facts.

*Value of local
treatment*

As an example of a number of experiments that have shown the value of local treatment a particularly convincing one carried out by Donald and Davidson in a large military hospital during the World War may be quoted. Over two hundred volunteers were treated only by general measures for a number of weeks, and their progress was compared with that of several hundreds in the same hospital under the same general treatment supplemented by irrigation of the urethra. At the end of about six weeks practically all these volunteers asked for local treatment, as it appeared to them that they were no better than on admission, and there had been a higher incidence of complications among them than in the men receiving local treatment.

*Risks of local
treatment*

As to the value of local treatment in shortening the chronic stages of the disease, nobody can have any doubt who has seen cases in which a single application through the urethroscope has brought to an abrupt end an attack which has persisted for many months. On the other hand, local treatment that is violent in the strength of chemicals or force of application can prolong the attack very greatly, even if it does not, as it often does, cause one or more local complications.

*Causes of
prolongation
of attack*

Other avoidable causes of prolongation are overdosing with vaccines and such indiscretions on the part of the patient as sexual intercourse, violent exercise, late hours, dancing, and indulgence in alcohol.

*Local
complications
and general
resistance*

Sometimes, however, a local complication, such as a prostatic abscess or an epididymitis, brings an attack of gonorrhoea rapidly to an end. The probable explanation of this apparently paradoxical behaviour is that the complication has stimulated the resistance to such a pitch that the tissues have completely expelled or destroyed the micro-organisms.

Apart from the above, the course of gonorrhoea differs in patients in a most unaccountable way. The young healthy man may retain his gonorrhoea for many weeks, whereas an old man or a weedy one who might not be expected to have any great resistance may be rid of it in a fortnight or less.

(3)—Complications

The complications of gonorrhoea in the male may conveniently be dealt with under five headings: (i) those due not directly to the gonococcus but to irritation by discharges; (ii) those caused by spread of the disease along ducts that open either into the urethra or very close to it; (iii) those due to transference of the gonococci to other parts of the body by fingers or towels; the chief of these are ophthalmia and proctitis; (iv) those due to infection of lymphatic vessels and glands; (v) those due to the gonococci being carried to other parts of the body by the blood-stream; the chief of these are all the affections grouped together as gonorrhoeal rheumatism, iritis and conjunctivitis, endocarditis, and others already mentioned in the section on pathology. Only the complications under (i) and (ii) will be discussed here.

*Classification
of
complications*

(i) Irritation by gonorrhoeal discharge may cause some balanitis, sometimes venereal warts, and sometimes acute oedema of the prepuce.

(ii) Spread of gonococcal infection along ducts connecting with or very close to the urethra may cause the following:

Tysonitis

This is an inflammation of one or both of Tyson's glands at the base of the frenulum. A swelling forms about the size of a pea or larger and may subside gradually or suppurate. Some of these abscesses communicate with the urethra and may cause repeated relapse or urinary fistula.

*Definition
and cause*

Para-urethritis

A para-urethral canal, opening on the glans either dorsally or ventrally to the urethral opening, sometimes runs parallel to the urethra for a few centimetres. It may communicate internally with the urethra and, if infected, may cause repeated relapse. These canals are usually very fine and correspondingly difficult to penetrate with chemicals or cautery designed to destroy them. Such a canal is occasionally the only part infected in sexual intercourse.

Course

Peri-urethral infiltrates

These are due to deep infection of follicles of the urethral glands (of Littre) and may reach such a size that they can be felt as swellings varying in size from a millet seed to a pea anywhere along the course of the anterior urethra. If such an inflammatory swelling grows no larger than a pea it may gradually subside, but often it suppurates and may increase to the size of a pigeon's egg, projecting from the ventral wall of the penis. If left untreated, the abscess usually bursts externally and may cause a urethral fistula.

Symptoms

Course

Peri-urethral infiltrates and abscesses are followed by the formation of more or less fibrous tissue, which must be prevented from causing stricture of the urethra. They may also cause repeated relapses unless they are drained properly, either into the urethra or externally.

Cowperitis

Cowperitis with abscess formation is an uncommon result of acute gonorrhoea, in spite of the fact that the duct opens in the floor of the bulb, where the inflammation is often most severe. When it occurs, there is usually a stricture of the urethra between the opening of the duct and the meatus causing back-pressure. Back-pressure being an important cause of infection of the bulbo-urethral (Cowper's) glands, it is easy to understand how such a complication can follow irrigation from a vessel placed at too great a height above the urethra. The abscess causes pain and swelling in the perineum close to the anus and is often wrongly diagnosed as prostatitis.

Diagnosis

The diagnosis is made by palpation between a finger within the anal canal and a thumb to one side of the perineal raphe. Chronic cowperitis is often overlooked, because the localizing symptoms are only vague, and it seems rarely to occur to the surgeon to palpate specially in the regions of these glands. Those who make a habit of doing so find there not very uncommonly a small hard swelling about the size of a cherry or less.

Besides inflammations of the gland, infection of the duct has to be reckoned with as a cause of chronicity and relapse. Occasionally the careful urethroscopist, searching the anterior urethra for a focus which is causing a chronic gleet or repeated relapses, lifts up a flap of mucous membrane in the region of the openings of the ducts of the bulbo-urethral (Cowper's) glands and releases a bead of pus, which reveals the cause of the trouble.

Prostatitis

Probably some degree of prostatitis occurs in all cases in which the infection spreads to the posterior urethra, but in most cases it is discovered only when the prostate is massaged in examining for causes of chronicity or in testing for cure.

Symptoms

In a comparatively small proportion of cases the infection is sufficiently acute to cause symptoms of discomfort in the rectum and deep perineum, pain on defaecation, and increasing dysuria. The prostate in such a case is swollen and tender, and the temperature may rise to 103° or 104° F. with correspondingly severe constitutional symptoms.

Prostatic abscess

The inflammation may subside in a day or two, but more commonly an abscess forms with resulting increase of symptoms according to the direction in which the abscess points. In most cases this is towards the deep urethra, and by pushing forward the posterior wall of the urethra the swelling causes increasing difficulty in micturition, until at the end of about a week or ten days there is often complete retention. The

catheter passed to relieve the retention usually hastens the bursting of the abscess, which relieves the patient from very great misery.

Far less commonly the abscess bursts into the rectum, and in rare cases it has opened in the perineum; isolated cases have been reported of its opening in the inguinal or the obturator region, in the peritoneal cavity, or through the sciatic foramen.

Other complications

Vesiculitis rarely gives rise to special symptoms. Commonly it is discovered in the systematic examination that is carried out in chronic gonorrhoea to find the remaining foci of infection.

Epididymitis and the other complications mentioned are dealt with under the appropriate titles.

Inguinal adenitis is not uncommon; it rarely ends in suppuration.

Lymphangitis of the penis, causing swelling of the prepuce, sometimes occurs; it seems often to have been caused by bad technique in irrigation.

(4)—Prognosis

It is unwise to predict to the patient the probable duration of his gonorrhoea, because it depends on the numerous factors already described (see p. 8). So far as the genital and lower urinary passages are concerned, it may safely be stated that suitable treatment eradicates the infection sooner or later, and that often in a very stubborn case cure is brought about suddenly by the discovery and treatment of a single focus. Local complications, as already mentioned, sometimes bring an attack of gonorrhoea quickly to an end. Any of them, however, especially prostatitis that has not ended in abscess formation, may delay for several months complete restoration to normality.

Prostatitis

In prostatic abscess the outlook depends largely on the direction in which the abscess points. When it bursts into the rectum it may cause a troublesome urinary fistula, and on the rare occasions on which it travels elsewhere than in the direction of the deep urethra or the rectum it may be dangerous to life. Some authorities do not regard the bursting of the abscess into the deep urethra as a good ending, because they say that a badly draining cavity is left, which becomes filled with contaminating urine and may later be the seat of prostatic calculi. The experience of workers in the venereal diseases treatment centres in England and Wales does not justify such a gloomy prognosis. Most of them would probably report that prostatic abscesses rarely burst elsewhere than into the urethra, and that complete and uneventful recovery is the rule.

Prostatic abscess

Stricture of the urethra is preventable. Probably in the past it was much more often than now a consequence of violent treatment and of neglect to make sure before dismissing the patient that not only was the calibre of his urethra unimpaired, but that there were no unresolved inflammatory collections round it.

Urethral stricture

For the prognosis in epididymitis see EPIDIDYMITIS, Vol. V, p. 89; for the prognosis in metastatic complications see articles dealing with the sites in which these occur.

(5)—Diagnosis

Acute

The diagnosis of acute gonorrhoea in the male is not difficult, if a specimen of the discharge, taken from the urethra after cleansing the meatus, is examined microscopically. It is difficult to excuse the mistake of diagnosing balanitis as gonorrhoea, because it can be avoided by taking the slight trouble of retracting the prepuce and looking at the meatus. A diagnosis of acute gonorrhoea should not be made until gonococci have been found, because a creamy discharge may be due to other causes, such as irritants in the urine after eating certain foods, such as strawberries and watercress; strong chemicals injected into the urethra for the prevention of venereal disease; infection by other micro-organisms; and the bursting of a symptomless chronic prostatic abscess. If the discharge is serous or sero-purulent, intra-urethral chancre should be suspected and the discharge examined in the fresh state for *Treponema pallidum*.

Chronic

In chronic urethritis the diagnosis of gonorrhoea may be doubly difficult, because gonococci appear in the secretions only intermittently and in small numbers. When the diagnosis of gonorrhoea has been established, many examinations may be necessary to locate the focus. It is safe to say that most medical men treating chronic urethritis to-day fail not only to diagnose its nature but to discover its location in the urethra, with the consequence that the disease is treated for many weeks or months, with little or no benefit, on the hit-or-miss principle of trying one or other method or remedy solely because it has at some time been recommended for the treatment of gonorrhoea, and without any clear idea of what it is intended to do. Such methods of management are all the more regrettable in view of the brilliant results which often follow the discovery and destruction of quite minute foci. It is worth while therefore to expend much time and labour over the diagnosis of chronic gonorrhoea.

Method of examination

Time is saved if the examination is carried out on a prearranged plan such as the following. The patient is asked to contain his urine for several hours before the examination. Then a specimen of urethral discharge is obtained if possible at the meatus, some being spread on a slide and some cultured. The anterior urethra is washed out with two pints of clear lotion, e.g. a solution of boric acid, mercuric oxycyanide, or sterile saline, using an irrigator nozzle as described under treatment or, better, a back-flow catheter. If no discharge is obtained at the meatus, the washings are saved and any threads in them examined in the laboratory. The urine is then passed in quantities of about two ounces at a time and the stream stopped when a clear threadless specimen is obtained. If the urine passed after washing out the anterior urethra is perfectly clear and free from threads, whereas discharge obtained at the meatus and wash-

ings of the anterior urethra contain pus cells, it is probable that all the trouble will prove to be located in the anterior urethra, but an examination of the prostate and seminal vesicles, with the fluid expressed from them, is always carried out. For this purpose it is arranged, if possible, that a little urine is left in the bladder (provided that threads have been cleared out of the urethra), because this urine is useful for washing out fluid expressed from the prostate and vesicles in the next step. If no urine has been left in the bladder, some clear lotion or saline is put there by the method described under Treatment (see p. 19).

The patient is put in the knee-elbow position, and the prostate and seminal vesicles are examined for irregularities and thickenings before being massaged from periphery to middle line to obtain a specimen of their secretions. The specimen may appear at the meatus, easily or on 'milking' the urethra, or may be obtained by centrifuging urine or lotion passed after the massage. Before removing the finger the region of the bulbo-urethral (Cowper's) glands is palpated by the method already described under Complications (see p. 10).

*Examination
of prostate,
vesicles, and
bulbo-
urethral
glands*

The anterior urethra is then examined with the urethroscope. For choice of instrument and exact technique of examination see *ENDOSCOPY OF THE URINARY TRACT*, Vol. V, p. 21, but the following may serve to show that, when a surgeon reports failure to find abnormalities in the mucous membrane, although the examination so far has revealed evidence of anterior urethritis, it should not be lightly assumed that there is nothing to be found; it may mean only that he has not searched carefully enough or has not been fortunate.

Urethroscopy

It is best to examine with the urethroscope on a day when no instrument has been passed and to begin the examination just behind the neck of the fossa navicularis instead of passing the instrument down to the triangular ligament before removing the mandrel. By examining from the meatus towards the bladder a view is obtained of the mucous membrane before it has been smeared with lubricant and irritated by the instrument. The mucous membrane is examined centimetre by centimetre and any doubtful spot probed with a suitable instrument. With the Harrison pattern of urethroscope probing is done with the end of the electric cautery, which can be made hot whenever desired by pressing a button switch in the handle by which the cautery is manipulated within the cannula. Sometimes abnormalities, such as a follicle oozing pus or a soft infiltrate or a granular patch, are seen at once; generally the signs are only slight and are easily missed, so that it may be only after a number of failures that a minute follicle is discovered which has caused a heart-breaking series of relapses. The successful examiner, methodically going over every bit of the surface, stops at each suggestive spot to try to squeeze a bead of pus to the surface or perhaps to lift up a flap in it to see if this will release pent-up pus.

Method

After examination with the urethroscope the routine instrumental examination can be concluded by the passage of a large curved sound into the bladder.

Blood tests A routine examination should always include tests of the blood: for the syphilitic serum reactions as a matter of ordinary precaution and for the gonococcal complement-fixation reaction.

A great deal has been written about the interpretation of the gonococcal serum test, and opinions are by no means unanimous about it, but the possibility that it occasionally gives non-specific reactions and that the reaction may persist in the patient's blood long after the gonococcal infection has been eradicated can be admitted, without denying its great value in both diagnosis and the assessment of progress under treatment.

Interpretation Reasonable interpretations of results of the test in different circumstances seem to be as follows.

Gonococci absent (i) In a case of chronic urethritis in which no gonococci have been found, a negative reaction would suggest that the urethritis was non-gonococcal. On the other hand, a positive reaction, although it might be due only to an infection which had been eradicated, would call for further tests to unearth gonococci which might so far have eluded the search. The blood test should be repeated periodically. If the reaction remains as strong as ever, it is unwise to conclude that the patient is not harbouring gonococci. If, on the other hand, the reaction diminishes in strength and eventually becomes negative, it seems to be a fair indication that the infection has gone.

Gonococci present (ii) In a case in which gonococci can still be seen in the discharge a negative reaction may be due only to the fact that infection is so recent that there has been insufficient time for a positive reaction to develop. If the case is one of chronic gonorrhoea, the negative reaction would suggest that the cause of the chronicity was the failure on the part of the patient to develop the antibodies to the gonococcus which are doubtless responsible in most cases for the natural eradication of the disease.

It has been noted by various authors that, if the complement-fixation test is carried out on a patient's blood at regular intervals, a fall in the strength of the reaction often precedes a troublesome complication. On the other hand, such a complication often then quickly causes the strength of the reaction to rise considerably, which may explain the fact already mentioned that many attacks of gonorrhoea have ended with the subsidence of such a complication as a prostatic abscess or an epididymitis.

(6)—Treatment

Prophylaxis The best preventive of gonorrhoea short of sexual continence is the wearing of a reliable condom, especially if previously an antiseptic ointment such as that of Gauducheau, as follows, has been applied:

Mercuric cyanide	—	—	—	—	0·10 parts
Thymol	—	—	—	—	1·75 parts
Calomel	—	—	—	—	25·00 parts
Lanolin	—	—	—	—	50·00 parts
Liquid paraffin	—	—	—	—	10·00 parts
Soft paraffin	—	—	—	—	to 100·00 parts

The condom must be removed with care to prevent any of the discharge covering it from contaminating the glans and meatus. If a condom has not been worn, the man should urinate in gushes so as to expel as forcibly as possible any contaminating material which may be in the entrance to the urethra. After this, washing well with soap and water followed by external disinfection with mercury and potassium iodide and urethral injection of an organic silver preparation, such as silver protein (protargol) 0.5 per cent, appear most likely to succeed. The treatment must be carried out as promptly as possible.

Abortive treatment by injection of strong concentrations of silver compounds is often recommended for those cases in which symptoms have only just started and the discharge is still mucoid. It is much better to give voluminous irrigations twice daily of potassium permanganate 1 in 4,000 by the method shown below (see p. 19) and to supplement them with urethral injections of silver protein 0.5 per cent two or three times daily. If these fail, the urethra has not been damaged, and the patient is no worse off for the attempt, as he may be after abortive treatment by stronger chemicals.

In order to treat intelligently and safely gonorrhoea which has reached the stage of a purulent discharge it is necessary to understand clearly that the expulsion of the gonococci is due mainly to the tissues and that, unless the tissues develop a strongly antigonococcal power, no treatment, however skilfully applied, will rid them of the disease. Probably in most cases the tissues would eventually rid themselves of gonococci, but practically always they do so more quickly when helped by treatment, and sometimes they would fail completely without this help. It follows that a consideration of prime importance in the selection of a treatment is its effect on the tissues. If it would damage these unduly, lowering their natural resistance, or would interfere with drainage, it would do more harm than good and should not be attempted. For the reasons given, local treatment with strong chemicals in the endeavour to destroy gonococci deeply embedded in the tissues has been practically abandoned, and one result is that stricture is becoming increasingly rare.

The danger of acting as if the tissues would respond to any sort of whip, however lustily applied, is seen in the results of unduly energetic treatment with gonococcal vaccines at the beginning of the attack. The way in which the disease continues unabated in some of the cases that have been treated with huge doses of vaccine, sometimes given intravenously, suggests strongly a prolonged negative phase and teaches the lesson that a body afflicted with gonorrhoea can no more be bullied into putting up a fight against the causal organisms than can one suffering from pneumonia, enteric fever, or any other disease of bacterial origin.

Methods of treatment can most conveniently be discussed under two main headings, general and local; the latter are divided into those applicable to the acute and subacute stages and those for the chronic.

Abortive treatment

Treatment in presence of purulent discharge

Danger of strong chemicals

Danger of vaccines

(a) General Treatment

At the outset the bowels should be properly emptied, and care should be taken throughout the attack to prevent constipation, because the passage of a hard stool might, for reasons given in the article EPIDIDYMITIS (see Vol. V, p. 88), cause this complication.

Rest in bed for the first week or ten days would be helpful but, for reasons of secrecy, is usually impracticable. Failing such complete rest, the movements should be as quiet as possible until the acute stage is over. Running and dancing should therefore be avoided, and a well-fitting suspensory bandage or a jock-strap should be worn. When the acute stage is over the amount of exercise should be increased; it is a mistake to restrict a patient rigidly to walking exercise until the very last test of cure has been passed, because moderate exercise during the declining stages does not usually aggravate the disease, and too much restriction only depresses the patient's spirits still further. Large quantities of bland liquids should be drunk and alcohol, spiced drinks, and coffee avoided. The diet should be as simple as possible, being made up chiefly of milky foods, vegetables, and fruit.

In most cases medicine is unnecessary, but a mixture containing potassium citrate 20 grains, tincture of hyoscyamus 15 minims, tincture of belladonna 5 minims, and infusion of bearberry or infusion of buchu to 1 fluid ounce given every four hours by day may help to allay urethral irritation. The same applies to sandal-wood oil and copaiba, but they are apt to upset the stomach and cause rashes; and, since the medical public has realized that none of them is a specific remedy for gonorrhoea, they have been largely discarded.

Urinary antiseptics

Urinary antiseptics, such as preparations of hexamine, mandelic acid, hexyl-resorcinol, pyridium, and acriflavine, are used hopefully by many workers but are certainly not strongly gonococcidial, as one can verify by making cultures of the threads in the urine of a patient being treated for acute gonorrhoea with one of them. It is possible that they sometimes prevent the gonococcus from gaining a hold in the posterior urethra, but in the acute stage it is doubtful if any advantage of using them counterbalances their disadvantages, such as expense, staining of linen by the dyes, and irritation of the bladder by the hexamine preparations. In the chronic stage when there is a mixed infection they may be quite valuable.

Sulphanil- amide

The discovery that sulphanilamide (prontosil, proseptasine) is effective against gonococci *in vitro* (Buttle and others) suggested that it might be useful in cases of gonococcal infection of the genito-urinary tract. Dees and Colston (1937) treated forty-seven such cases, in thirty-six of which the gonococci in the urethral discharge disappeared in less than five days. In five cases the subjective symptoms disappeared completely and there was marked diminution in the amount of urethral discharge, but gonococci were still present. In three cases there was no demonstrable response to the drug; in three others the infection recurred on discon-

tinuance of the treatment, but in two of these the infection disappeared following a second course of sulphanilamide. In no instance did the infection advance, even in cases which did not respond to treatment. With few exceptions the patients received, in four divided doses a day, 4·8 grams of sulphanilamide daily for two days, 3·6 grams daily for three days, and then 2·4 grams daily for from four to eight days. Some patients tolerated a daily dose of 1 gram of sulphanilamide per twenty pounds of body-weight for as long as a month without serious ill effects. Nevertheless dizziness and lassitude were not uncommon during treatment and sulphaemoglobinaemia occurred in one case of the series. (See also Vol. III, p. 521, and Vol. V, p. 157.)

Felke obtained even better results with the allied compound tested under the experimental number DB 90, and Grütz with DB 90, DB 87, and DB 32. The best results were given by DB 90 in patients who, having had the disease for a few weeks, had developed some power of overcoming the infection; consequently the results in women, who delay seeking treatment longer than do men, seem to be particularly good. Grütz had most success with DB 87 but in some cases found that, when the response to this was unsatisfactory, DB 90 was effective, and vice versa. *Allied compounds*

On the value of vaccines opinions are hopelessly divided. Some deny their value in any form of gonorrhoea, some think them useful only in the complications, and a third group believe them useful in all forms and stages of the disease. I have studied this question for over twenty-five years in parallel series of cases treated with and without vaccine, in cases treated with different doses and brands, and by observation of the effect of vaccines on the gonococcal complement-fixation test, and suggest that the following facts are pertinent to this question. *Value of vaccines*

(i) The patient's acquired resistance is a very important factor in determining the expulsion of the gonococci from the tissues, and there is some reason for believing that the gonococcal complement-fixation reaction is a gauge of this resistance.

(ii) Very large doses of gonococcal vaccine given in the acute stage of gonorrhoea seem often to have prevented the development of the gonococcal complement-fixation reaction in the usual time, a few weeks after the commencement of the attack. At the same time they certainly seem also to have prolonged the attack.

(iii) In cases of persistent gonorrhoea, in which the gonococcal complement-fixation reaction was negative or only doubtful, the administration of a suitable gonococcal vaccine in suitable doses has very often caused the reaction to become positive, and this seems to have been all that was required to end the attack of gonorrhoea.

(iv) On the other hand, injection of gonococcal vaccine may fail to stimulate the development of a positive complement-fixation reaction, as can be seen by anyone who makes a practice of having the blood tested after the patient has had 'a course of injections of vaccine', and in such cases it does not seem to influence the course of the disease.

The conclusion from all this seems to be that vaccines in suitable doses

materially assist the treatment by stimulating the resistance, but they can do harm if given in doses that are too large, particularly at a time when the tissues are coping with large doses of toxin evolved from the infecting micro-organism. Also, as some brands of vaccines seem to have no antigenic power, the best results, or even any results of value, cannot be expected from the prevalent custom of blindly administering courses of vaccine according to some scheme of dosage provided by the manufacturers; the effect ought to be watched by the blood test.

*Method of
vaccine
treatment*

The best time to begin vaccine treatment seems to be when the symptoms are abating and the discharge has become no more than a morning gleet. This is the time when the vaccine may be like the whip at the end of the race. The gonococcal complement-fixation test is valuable at this stage, and vaccine treatment is especially indicated if the reaction is negative or only weak. It is impossible to say exactly how many millions should be given and at what intervals, because different brands differ greatly in toxicity and patients differ very greatly in their reaction. The principle should be to begin with quite a small dose, say 10 to 15 millions, and to increase according to the effect, the aim being to produce a mild local and general reaction. Generally in the early stages of the treatment the dosage can be increased by about 50 per cent at each successive injection and injections given twice a week until a definite general reaction has been produced. After this increments of 25 per cent or less, according to reaction, and intervals of a week are usually suitable.

Dosage

*Site of
injection*

With regard to route, intracutaneous injection (conveniently into the skin of the upper part of the thigh) has the important advantages that it seems to have a better antigenic effect and the local reaction (zone of erythema) following it can be gauged much more easily than that following a subcutaneous injection. Successive injections should be given into sites a few inches removed from those of previous injections.

After a few weeks the blood should be tested again, and, if the complement-fixation reaction has not become distinctly stronger, a change of brand of vaccine or a modification of dosage should be considered.

*Fever
treatment*

For a long time it has been believed that gonococci die at temperatures easily tolerated by the body, and various workers, acting on this, have treated the disease by inducing malaria and by the application, either local or general, of diathermy. The results have, however, not been uniformly successful, and the methods have not gained any great popularity. Recently, however, as already mentioned (see p. 4) the matter has been put on a more precise footing by the researches of Carpenter and his colleagues, who found that 99 per cent of their strains of gonococci were destroyed by a temperature of 41° C. for four hours. Acting on this, various American workers, notably W. M. Simpson, and A. V. Desjardins, L. J. Stuhler and W. G. Popp, have tried with very successful results physical methods of inducing high temperatures. Desjardins and his colleagues induced temperatures of 41.1° C. to 41.7° C. and maintained them for six to eight hours by placing the patient in an air-conditioned chamber, the Kettering hypertherm,

invented at the Kettering Institute for Medical Research, Dayton, Ohio, by Kettering and Simpson. Sitzings were given every two or three days for four or five times, which sufficed to eradicate the disease in most of their cases. The treatment, of course, requires the greatest care, but its possibilities can easily be imagined.

In a recent communication Carpenter and Boak (1937) showed that the thermal death time of 250 strains of gonococci at 41.5° C. had varied from 6 to 34 hours, with a mean of 16.1 hours; and Warren, in an analysis of 163 cases of gonorrhoea, showed the value of taking the thermal death time of the organism affecting the individual patient as a guide to the duration of sittings. *Significance of thermal death time*

(b) Local Treatment

Local remedies can be applied to the urethra in acute gonorrhoea in the form of lotions introduced by an irrigator or a syringe, or in ointment form, or in medicated bougies. There are many objections to the use of ointments and bougies in acute gonorrhoea, and these methods will not be described. As technique is very important in the introduction of lotions into the urethra, irrigation and injection will be described first, before the various lotions are discussed. *Acute gonorrhoea*

In irrigation, from one to two pints of lotion are made to flow in and out of the urethra. The requirements are a two-pint irrigator vessel of rubber, glass, or enamelled iron; about four feet of rubber tubing, half an inch in diameter; a nozzle (of glass or metal) with a bluntly conical tip; and a clip to compress the tubing when required. The vessel is set at a height of three feet or less above the penis and filled with the selected lotion, which is at the temperature of the body. Air is removed from the tubing by holding the nozzle end high above the level of the lotion and then gradually lowering it, after releasing the clip, until the lotion is flowing freely from the end; the clip is then re-applied while the patient is being prepared. He passes urine, and the glans around the meatus is cleansed with some antiseptic solution, after which he may stand, sit, or lie for the introduction of the lotion. The clip is released and the flow then controlled by the finger and thumb pinching the tube behind the nozzle. The tip of this is applied to the meatus, while its stem points along the urethra, and the compression of the tube is released to allow the lotion to distend the anterior urethra. As soon as it has done so, the tubing is pinched and the nozzle withdrawn from the meatus to allow the lotion to flow out of the urethra. The anterior urethra is filled and emptied in this way about six times, and the operator then decides if he will try to get the lotion to flow into the bladder. *Irrigation*

Opinions are divided on the advisability of doing this in the absence of signs of posterior urethritis. Those who oppose it say that it is apt to cause posterior urethritis and such complications as prostatitis and epididymitis. I believe that it prevents posterior urethritis and does not cause local complications if only weak lotions are used and the *Effect on posterior urethra*

compressor urethrae is persuaded to relax, no attempt being made to force it by elevating the irrigator above a maximum of $3\frac{1}{2}$ feet. The irrigator is kept at the same level, and when the urethra feels distended the patient is asked to let his bladder empty itself. That is, he is not to empty his bladder forcibly but as if he had long wanted to do so and could now let the urine pour out. Usually this plan has the effect of causing the sphincter to relax, and the lotion flows easily down the wide-open urethra into the bladder. It is a mistake to think it necessary to increase the pressure to get the sphincter to relax; it is far better to keep the irrigator below a height of three feet and to raise it only when the bladder will persist in forcing the fluid back into the irrigator. As a rule it is sufficient to fill the bladder three times with the lotion. Generally two irrigations a day at intervals of about twelve hours are better than one. If only one irrigation can be given, it is best to supplement it with injections given with a small syringe.

Lotions for irrigation

The lotions commonly used for irrigation are potassium permanganate, 1 in 16,000 to 1 in 4,000 (generally 1 in 8,000); acriflavine, 1 in 8,000 to 1 in 5,000; silver nitrate, 1 in 20,000 to 1 in 5,000 (to be made up with distilled water); mercuric oxycyanide, 1 in 8,000 to 1 in 4,000, generally for mixed infections and not to be used when the patient is taking iodine in any form; and boric acid. Of all these potassium permanganate is by far the most popular in Great Britain, but occasionally it is a complete failure, and probably the best substitute then is acriflavine. Some workers use a mixture of potassium permanganate and mercuric oxycyanide, 1 in 8,000 of each.

Injection

Injections can be given with a fairly large syringe operated by the surgeon or with a small one of about two-drachm capacity usually for use by the patient. It is difficult to see any advantage of the large syringe over the irrigator except in economy of lotion. The small syringe is very popular, because it can easily be hidden and used secretly by the patient. It has the disadvantage that it treats only the anterior urethra, can easily cause posterior urethritis, and is probably often the means of introducing other organisms into the urethra. Many of the objections to the use of the small syringe would be removed if a proper pattern of syringe were used and the patient were taught the art of using it. One of the best patterns is that designed by Canny Ryall, a syringe of two-drachm capacity with a glass nozzle and operated by a one-ounce rubber bulb, which is more convenient and manageable than a piston.

Method of injection

The correct method of using a glass syringe is easily learnt by the patient, but it should not be assumed that he can syringe his own urethra until he has been seen to do it properly. After the patient has urinated and the glans and meatus have been properly cleansed, the nozzle of the syringe, which has been filled with about two fluid drachms of the selected lotion, is applied to the meatus and the bulb steadily squeezed to expel the lotion into the urethra. The lotion is held there for about half a minute before being allowed to escape, and the operation is repeated twice.

The lotions commonly used with the hand syringe are the same as those used for irrigation, but for most purposes one of the organic silver preparations is probably better. Of the multitude of such compounds that have been put on the market the following appear to be the most useful: protargol (silver protein), 1 in 800 to 1 in 200; argyrol (mild silver proteinate), 3 to 5 per cent; albargin, 1 in 500; targesin, 1 to 5 per cent; choleval, 1 in 400 to 1 in 100. The silver preparations may do harm if used for too long a period or in too great a strength. A good routine is to get the patient to inject a silver preparation about twice a day and to irrigate night and morning with 1 in 8,000 solution of potassium permanganate.

Lotions for injection

When improvement is continuous, the local treatment should be continued for about a week after all discharge has ceased.

Length of treatment

If recurrence does not follow suspension of treatment for about a week, the various tests of cure described later should be carried out.

When the discharge persists for a number of weeks, either as a slight and watery gleet seen at the meatus or as heavy threads in the urine, or recurs shortly after irrigation and injections have been stopped, the treatment appropriate for chronic gonorrhoea is indicated. As this requires the passage of instruments into the urethra, it should not be started until the urine is quite clear. Instrumental treatment during the earlier stages often provokes such complications as prostatic abscess and epididymitis.

The two chief causes of chronicity and relapse are: (i) failure to develop an adequate antigonococcal power, demonstrated by a negative or a doubtful gonococcal complement-fixation reaction and best treated by a vaccine, of which the effect should be gauged by periodical repetitions of the blood test; and (ii) imperfect drainage of some focus in which the infection still smoulders. Badly draining foci are probably the cause of chronicity and relapse in most cases. Unfortunately, few workers at present seem to take the trouble to find these foci, with the result that in very many cases of chronic gonorrhoea, before a systematic search undertaken at long last has located the trouble in the anterior urethra, the normal prostate has been massaged regularly and sounds have been passed into the bladder without any other indication for these manœuvres than the fact that they are mentioned in text-books as being useful in chronic gonorrhoea.

Chronic and relapsing gonorrhoea

The steps to be taken to discover badly draining foci have been described on page 12, and it is necessary now only to describe their treatment when discovered. In the anterior urethra light cauterization seems to be the most effective method of opening follicles or crypts in which the infective secretion is partially pent up. This view is based on a fairly substantial number of cases in which, after systematic dilatation, ringing the changes on the many chemicals used for irrigation, and the use of vaccines and other methods of treatment have completely failed to effect a cure, a bead of pus has been seen through the urethroscope oozing from some spot on the mucous membrane, and the spot in

Cauterization

question has been cauterized, with the result that no further sign of gonorrhoea has been seen in that patient.

Dilatation

It is useful to supplement cauterization by touching the treated spot with a swab soaked in 10 per cent mercurochrome solution and by systematic dilatation of the urethra with an expanding (e.g. Kollmann) dilator or with metal sounds at intervals of about five days to a week. In using the mechanical dilator the degree of stretching is largely governed by the patient's sensations. No anaesthetic is used, and at any one sitting the stretching is carried only very slightly beyond the stage at which the patient complains of any discomfort. It is often useful to massage the urethra gently from without while the dilating instrument, Kollmann dilator or sound, is within the urethra.

Irrigation

Before and after using instruments the urethra should always be irrigated with an antiseptic lotion, such as mercuric oxycyanide 1 in 8,000 to 1 in 4,000 (unless the patient is taking iodine in any form), boric acid, or silver nitrate 1 in 10,000. Potassium permanganate should not be used for this purpose, as it makes the passage of instruments difficult or even impossible.

Secondary infections

It should be borne in mind that an anterior urethritis which was originally gonococcal may be kept active by other micro-organisms after gonococci have disappeared. The micro-organisms commonly found in these cases are staphylococci, streptococci, diphtheroid bacilli, and *B. coli*, of which the cocci may sometimes look very like gonococci. Strictly speaking, such cases belong to another section, as they are not gonococcal; but, as they commonly follow on gonorrhoea and it is not until they have been treated for a number of weeks that gonorrhoea can safely be excluded, it seems appropriate to discuss the treatment here. For such secondary infections potassium permanganate seems to be useless, and commonly the more definitely antiseptic lotions are used in conjunction with urinary antiseptics by mouth or by intravenous injection. Sometimes in such a case filling the anterior urethra with 5 or 10 per cent mercurochrome solution is effective.

Appearance on urethroscopy

In some cases urethroscopy reveals a very striking condition of the lining of the urethra, which is studded with minute nodules. The condition, which is venereal in origin, is commonly referred to as sago-grain urethritis. Its clinical and endoscopic pictures tally closely with the descriptions by Waelsch, Glingar, and others of the type of urethritis known on the Continent as Waelsch urethritis. It was described by Scherber under the heading 'Einschluss urethritis, Urethritis trachomatosa sive protozoica', although Scherber acknowledged that Waelsch first described it. It seems to yield most quickly to systematic light cauterization of the nodules.

Phosphaturia

Sometimes irritation by the urine is responsible for maintenance of a urethritis, and probably one of the commonest causes of this kind is phosphaturia. If there is any suspicion of this, each sample of urine passed in the twenty-four hours should be examined, as that which is passed in the consulting-room may be quite clear. If phosphaturia is

discovered, the salts should be kept in solution by steps designed to keep the urine sufficiently acid.

If the tests have shown that, with or without trouble in the anterior urethra, the disease still persists in the posterior urethra, it is practically certain to be in the prostate and/or one or both of the seminal vesicles. The usual treatment then is to empty these organs every five or seven days by massage, and it is advantageous to do this after irrigating the whole urethra with an antiseptic lotion some of which has been left in the bladder. It cannot be emphasized too strongly that prostatic and vesicular massage should be avoided during the acute and subacute stages of gonorrhoea, as when carried out too early it is very often followed by epididymitis. If it must be done then, e.g. when there is a metastatic complication or a subsiding prostatic abscess, the danger of epididymitis seems to be lessened by giving atropine by suppository, injection, or mouth. *Prostatic massage*

Diathermy applied to the prostate and vesicles after massage of these organs seems to give better results than massage alone. Originally it was believed that diathermy destroyed the gonococci by the production of heat in the tissues, but a more probable explanation is that it has a poulticing effect and so promotes drainage. *Diathermy*

In chronic gonorrhoea excessive treatment may be responsible for a persistent urethritis, and a rest from local applications has often resulted in the disappearance of all signs.

If treatment on these lines fails to eradicate gonorrhoea, pyretic therapy in some form, such as malaria, intravenous injections of dead organisms, the heated chamber, or diathermy, should be considered; for details see DIATHERMY, Vol. IV, p. 34; ELECTROTHERAPY, Vol. IV, p. 490; and NEUROSYPHILIS. *Pyretotherapy*

Para-urethritis

Adventitious canals adjoining the urethra should be destroyed by the electric cautery, by fused caustic on a fine probe, or by injection with a strong solution of silver nitrate through a blunt needle. Often it is very difficult to get any instrument into one of these canals; the difficulty may be overcome sometimes by distending the canal through a capillary pipette connected to a source of air or oxygen. *Treatment of complications*

Tyson and peri-urethral abscesses

These are best emptied by aspiration through a hollow needle connected to a syringe. After the contents have been removed, the cavity can be injected with colloidal silver or with a 1 to 2 per cent solution of mercurochrome. The operation may have to be repeated two or three times as the cavity refills. Aspiration has the advantage over open incision that it is not likely to be followed by a urinary fistula. After any peri-urethral inflammation, whether it has resulted in abscess or not, it is important that the patient be kept under treatment by dilatation of the urethra until it is certain that no stricture will follow. *Aspiration*

Cowperitis

Abscess of a bulbo-urethral (Cowper's) gland is treated by open incision; chronic inflammation may require excision of the affected gland.

Prostatitis

Acute prostatitis may subside under rest in bed, a smart purge, diathermy to the prostate, and suppositories containing atropine sulphate $\frac{1}{10}$ grain, with morphine sulphate $\frac{1}{4}$ grain, night and morning. If the symptoms become worse, these measures should be supplemented by frequent hot sitz baths. In due course it is necessary to decide whether to open the abscess through the perineum or to help it to burst into the urethra. Some, chiefly American, workers believe that the opening should always be through the perineum, whereas most others reserve this operation for cases in which the abscess is pointing elsewhere than into the urethra. In my experience recovery after the abscess has opened into the urethra is usually quite satisfactory. When retention is imminent or complete, the passage of a silk-web catheter, besides emptying the bladder, often hastens the bursting of the abscess. Some use a metal sound for the purpose, but it is much more painful. After the abscess has burst it should be kept open by gently massaging the prostate each day, and diathermy is very valuable in hastening recovery.

For the treatment of other complications see articles on epididymitis, arthritis, and affections of other parts of the body that were mentioned in the section on Pathology as sometimes infected by the gonococcus (see p. 5).

(7)—Tests of Cure

Most diseases other than gonorrhoea and syphilis are regarded as cured when they no longer incommode their victims. In gonorrhoea the standard is necessarily far higher, namely, complete exclusion of the infecting organism. To determine when this has occurred is by no means easy, owing to the ability of the gonococcus to lie hidden below the surface without causing symptoms for days, weeks, or months. No single test can be relied upon to determine the fact that the disease has been eradicated, because none is infallible. Instead, every conscientious worker in this field applies a series of tests, and eventually, on the strength of none of them having unearthed a gonococcus, he comes hesitatingly to the conclusion that, as far as it is humanly possible to tell, the patient is no longer a gonococcus carrier.

Scheme of tests

The tests differ with different workers, but the following series appear to be as reliable as any. At the outset it is assumed that no sign of the disease has been seen for at least a week after the suspension of treatment and, if there is any urethritis, a large number of examinations of the urethral secretion have failed to disclose any gonococcus. The patient is provided with slides, after the proper method of spreading urethral secretion on them has been shown to him. This is because any

recurrence of discharge will probably appear only before the first urination, long before the patient can get to his medical adviser. *Collection of discharge*

On the first day the prostate and vesicles are massaged, specimens of the secretion are taken for cultural and microscopical tests, and the rest is left in the urethra as long as possible. This is on the principle that, if any gonococci are still in the prostate and/or vesicles and are forced on to the surface of the urethra, they will cause a recurrence of the urethritis. At the same sitting a specimen of blood is taken for a gonococcal complement-fixation test. *Prostatic massage* *Blood test*

At the next sitting, a week later, the canal is examined with the urethroscope and then fully dilated with the Kollmann dilator. A full-sized sound is also passed into the bladder. By these tests one is assured that the urethra is left undistorted, and the instrumental interference tends to provoke a relapse. At this sitting a large dose of vaccine is given intracutaneously. *Urethroscopy* *Vaccine*

If there is not any recurrence of discharge in consequence of this provocation and the blood reaction is negative, presumption of cure is fairly safe, but it is a good plan to repeat the tests in three months.

The difficulty is to know what to do if examination of the discharge shows pus cells, although gonococci are not found. If the blood reaction is negative at the first test or becomes negative during the period occupied by the tests of cure, and many repeated examinations of the secretions fail to show gonococci but do show another reason for the inflammatory signs, e.g. an infection with secondary organisms, it seems reasonable to put the patient on three months' probation and to repeat the tests at the end of this time. If then there is no change, it is safe to assume that the gonococcal infection has gone.

Greater difficulty arises in cases in which the gonococcal complement-fixation reaction remains just as positive as when first tested. Some authorities believe strongly that in such a case the patient is a gonococcus carrier, although he may not show any other abnormality. I do not hold this view, having seen many patients with reactions that have remained unchanged for years without any other sign of gonococcal infection in either themselves or their wives. Such cases appear to be of the kind mentioned by various authors as naturally retaining immunity reactions for long periods. That such persons exist is shown by the length of time some who have never had gonorrhoea have been known to retain a positive gonococcal complement-fixation reaction after a few injections of vaccine. At the same time a gonococcal complement-fixation reaction must not be regarded lightly. It calls for a further careful search for gonococci in the patient.

6.—GONORRHOEA IN ADULT FEMALES

(1)—Clinical Picture

577.] The passages most likely to be affected primarily by gonorrhoea in women are the urethra and the cervical canal, and in a much smaller

proportion one or both of the greater vestibular (Bartholin's) ducts and glands. The vulva and vagina are affected secondarily by irritating discharges.

Early symptoms

The first symptoms are abnormal discharge from the vulva and vagina, with perhaps some burning on micturition, some soreness of the parts, and pelvic heaviness and discomfort. Sometimes the signs are very acute with a highly inflamed oedematous and excoriated vulvar orifice, profuse discharge, and such great discomfort as to force the patient to stay in bed. More often the symptoms are quite mild, and in many cases merely suggest to the patient a slight increase of a discharge which she has come to regard as a normal affliction of women, not worth the trouble of asking medical advice for (see LEUCORRHOEA).

Papillomas

The irritation of the vaginal discharge may stimulate the growth of papillomas so much that the whole genital area and perineum may be covered with a large cauliflower-like mass of warts.

Bartholinitis

If a greater vestibular (Bartholin's) gland is affected, a swelling forms in the posterior third of the labium majus on that side and ultimately an abscess. At the same time, the opening of the gland duct on the inner side of the posterior end of the labium minus is reddened and a bead of pus may be expressible from it. Occasionally a peri-urethral abscess occurs as in males.

Proctitis

Proctitis occurs in more than half the cases but rarely gives rise to any symptom, being discovered only by examinations of specimens of discharge scraped from the wall of the rectum.

Salpingitis

In a comparatively high proportion of cases the infection spreads to one or both of the Fallopian tubes, and the result is an acute attack of pelvic pain on the affected side with a smart rise of temperature. The trouble usually settles down in a few days but exceptionally may proceed to peritonitis with oöphoritis. General complications are the same as those which occur in the male.

(2)—Diagnosis

Collection of specimen

Examination should be carried out with the patient in the lithotomy position, as this gives a better opportunity of taking specimens easily for laboratory tests. The urethral orifice is first examined and cleansed of external discharge before any attempt is made to obtain a specimen from the canal. This is usually done by massaging it from behind forwards through the anterior wall of the vagina. Naturally a good specimen is more likely to be obtained when the patient has contained her urine for three or four hours. A bead of pus may be forced out, or the specimen may be obtained only by passing a platinum loop or a dressed urethroscopic swab-stick down the canal. Sometimes a bead of pus can be obtained by massage of the urethra immediately after the patient has urinated; this suggests an infection of one or both of Skene's tubules, the openings of which may be seen just within or adjoining the meatus. Any specimens obtained are spread on slides and on culture media. To transfer a specimen from a cotton-wool swab it is best to

roll it over the surface of the slide or medium as quickly as possible after it has picked up the specimen.

The mucous membrane around the meatus should be examined for inflamed gland ducts. The openings of the ducts of the greater vestibular (Bartholin's) glands are inspected, and the region of the glands in the posterior third of each labium majus is squeezed between a finger or thumb inside the vagina and a thumb or finger outside on the labium; any swelling is very suggestive. *Glands*

The cervix is exposed by means of a suitable speculum, such as Brewer's modification of the Cusco bivalve, which is very easy to introduce and is self-retaining. The secretion should be cleaned from the external os uteri before specimens are taken on a slide or for culture. *Cervix*

Specimens should always be taken from the rectum by rubbing the anterior wall with a stout platinum loop. Cultures from this region should be made on plates of medium, as tube cultures commonly fail. Perhaps plates would be better for specimens from the urethra and cervix, but tubes are simpler and usually succeed. If a laboratory is not near at hand, it is best to collect the discharge by pipetting it drop by drop into a sterile tube and then collecting the product into a capillary pipette, one end of which is sealed up. *Rectum*

Before the conclusion of the examination the uterus and the tubes should be palpated bimanually for the detection of undue enlargement and tenderness. *Uterus and tubes*

A specimen of blood should always be taken for the gonococcal complement-fixation and syphilitic serum tests. *Blood test*

(3)—Treatment

The general treatment is practically the same as for gonorrhoea in the male, but in the female pyretotherapy will probably prove more generally useful. W. Bierman and E. A. Horowitz combine systemic elevation of the body temperature with pelvic diathermy. The patient lies within a hood containing carbon-filament lamps while pelvic diathermy is applied by means of a vaginal electrode with rounded edges and four dispersive electrodes, one on the abdomen, one on the back, and one 3" by 5" on the outer side of each thigh. According to their communication to the First International Conference on Fever Therapy, New York, 1937, a systemic temperature of 105.5° to 106.5° F. is maintained for twelve hours during seven of which the vaginal temperature is held at 109° to 110° F. The authors claimed that their combined method had been successful in 113 out of 121 cases and in their last series the average number of sittings required to bring about disappearance of gonococci was 1.4 per patient. *Pyreto-therapy with diathermy*

(a) *Acute Gonorrhoea*

While symptoms are very acute it is best to be content with frequent hot sitz baths. When symptoms have subsided each of the canals needs to be dealt with separately. The same general principles apply as in *Local treatment*

males. As antiseptics which can be tolerated by the mucous membrane cannot reach gonococci in the depths of the tissues, the chief dependence is on adequate drainage. Much depends on the question whether the treatment can be applied by a medical attendant or nurse every day or whether the patient must carry out most of it for herself.

Urethritis

If a nurse is available, daily irrigation with potassium permanganate, mercuric oxycyanide, 1 in 8,000 in each case, acriflavine, 1 in 5,000, or any of the other lotions used in gonorrhoea of males serves quite well. A good nozzle for the purpose is a Kidd's catheter, a blind-ended glass tube with a number of small holes in it close to the blind end. The lotion can be allowed to enter the bladder quite as freely as in males.

If the patient must carry out most of the treatment, she can sometimes be taught to irrigate herself with the help of a mirror but probably would find it most convenient to inject and for the purpose can use a Canny Ryall syringe with the silver preparations mentioned in the treatment of males (see p. 21).

It is a good plan to insert into the urethra every five or seven days a probe dressed with cotton-wool and soaked in 5 to 10 per cent mercurochrome solution. Usually the urethritis clears up easily, but one or both of Skene's tubules or some peri-urethral follicles may be infected. In these cases probably the quickest results are obtained by destroying the infected canal with the electric cautery. Some workers use a 1 to 5 per cent silver nitrate solution injected through a blunt needle.

*Cervicitis
Cleansing
of vagina*

In cervicitis, if a nurse can apply the treatment, the following routine often serves well. The vagina is cleansed by douching at low pressure with a mild antiseptic lotion such as potassium permanganate, 1 in 8,000, containing sodium bicarbonate, 120 grains to one quart, added just before use; mercuric oxycyanide, 1 in 4,000; chloramine-T, 1 in 4,000; or 1 per cent dettol. Alternatively the cleansing may be done by swabbing first with cotton-wool soaked in saturated solution of sodium bicarbonate and then with dry cotton-wool mops. After the vagina has been cleansed in this way, one end of a loose dressing consisting of a yard of gauze folded lengthwise in four and soaked in glycerin of borax, ichthammol 5 per cent in glycerin, eucalyptus oil 5 per cent in glycerin, or glycerin with some other antiseptic in non-irritating strength is pushed up through the speculum to lie in the posterior fornix, while the remainder lies loosely in the vagina with one end projecting from the vulva to facilitate removal the following morning. The principle of this method of treatment is to encourage that outpouring of discharge which seems to be nature's method of expelling the gonococcus.

*Endocervical
applications*

The question arises whether or not it is advisable to apply any medication to the cervical canal. Some workers would leave it alone, fearing that interference here may precipitate salpingitis. This has not happened in my experience, so it appears to be safe if done carefully. Moreover, endocervical applications seem to have proved very useful. The canal should first be cleansed by swabbing, and for this purpose a urethroscopic swab seems to be more suitable than one on a Playfair's probe,

because being thinner it is less likely to scrape the mucous membrane roughly or to act as a piston driving secretion through the internal os. In any case, to avoid the latter action, the swab should be inserted by a twisting motion.

The multitudes of medicaments that have been advocated for application to the endocervical mucosa in gonorrhoea make the choice of a suitable one difficult. Some authorities, more especially in the past, have prescribed chemicals in such concentrations as to be caustic; others have recommended the actual cautery. Whatever may be done in chronic stages of gonorrhoea, such methods are not desirable in the acute disease. Not only do they fail to destroy gonococci in the depths of the tissues, but they cause necrosis of the mucous membrane and make it a good breeding-ground for secondary organisms. Whatever application is chosen should therefore be non-irritant. I have used mercurochrome since 1923, when I found that, as judged by inspection through a urethrosopic cannula, even a 25 per cent solution did not seem to be unduly irritant to the vagina of young children. The strength used as a routine measure to the cervical mucous membrane has been 10 per cent. It has been used for the cervical canal and vagina by the following method, which was first elaborated for patients who could not have the help of a medical attendant or a nurse more often than once or twice a week. After the cervical canal has been cleansed, a urethrosopic swab soaked in the solution of mercurochrome is twisted into it and left there, while with another swab on a Playfair's probe the fornices and as much of the vaginal wall as possible are painted with the same solution. The swab in the cervical canal is changed for a new one and the second swab left there for a few minutes. The application is made every five to seven days. Although it cannot be claimed for the method that it destroys gonococci in the deeper parts of the mucous membrane, it does penetrate well, and the high concentration insures prolonged action before the antiseptic has been diluted by secretions to a non-bactericidal strength.

*Choice of
medicament*

*Method of
application*

Between sittings the patient douches daily at low pressure with a mild lotion, such as potassium permanganate 1 in 8,000 to 1 in 4,000, acriflavine 1 in 5,000, mercuric oxycyanide 1 in 8,000, or dettol 1 per cent, until the discharge is no longer soiling the clothes. It is a mistake to continue douching too long, and as soon as the discharge has abated it can be carried out much less often, say every other day at first and then at lengthening intervals. Between douches a medicated pessary, such as acriflavine, 1 in 500, or 1 per cent ichthammol, can be inserted daily or a vaginal tablet of devegan or stovarsol pushed far up into the vagina one to three times a day. Devegan and stovarsol contain the same arsenical compound that is used so successfully against *Trichomonas vaginalis*, and either is a very convenient adjuvant remedy in the treatment of gonorrhoea of the female.

Douching

R. S. Statham considers that the mercurochrome solution should not be stronger than 1 per cent. His method is to apply this daily to the

cervix and vagina while the latter is fully stretched with a fenestrated speculum. He strongly deprecates endocervical applications and undue douching. On the other hand, L. Brady considers a 20 per cent solution a perfectly safe strength of mercurochrome for application to the endocervix and has reported a number of satisfactory results from the use of mercurochrome in this concentration twice weekly. He has not seen any harm follow the applicator charged with the dye sliding through the internal os to the fundus. He also paints the whole vaginal portion of the cervix with the same solution. Another application for which good results have been claimed by many writers is an acridine dye combination with arsenic which is known in Germany as flavadin and sold in Britain as mesodine. It is injected very slowly into the cervical canal each day with a special syringe. The dose is increased by 0.5 c.c. from 0.5 c.c. to 3 c.c., provided that irritation does not follow.

(b) *Chronic Gonorrhoea*

The problem is similar in principle to that in chronic gonorrhoea of the male; the cause lies in failure of the tissues to develop an adequate resistance to the gonococcus and/or in inefficient drainage of one or more foci. If the gonococcal complement-fixation reaction is not strongly positive several weeks after the onset of the attack, a suitable vaccine should be given on the lines already discussed. It is particularly in chronic gonorrhoea in females that malarial treatment has been successful.

Drainage

With regard to drainage, foci in and around the urethra can be dealt with by the cautery as already mentioned. The cervix is a far more difficult problem. Obvious retention cysts on the os, Nabothian follicles, can be opened by the cautery, and linear cauterization of the mucous membrane of the cervical canal is claimed by many workers to act well. L. E. Burch splits the cervix sagittally in order to convert a closed canal into an exposed surface. He advocates this treatment particularly in pelvic inflammation.

Diathermy

Before any operative procedure is adopted diathermy to the cervical canal is worth a trial. My experience of diathermy in acute gonococcal cervicitis at the St. Thomas's Hospital V.D. Clinic was at first disappointing. As gonococci could be cultivated from the secretions immediately after prolonged sittings, it did not seem likely that the hypothesis of its action—destruction of gonococci by the heat generated in the tissues—was being borne out by practice. Recently, however, the method was reinvestigated there by J. W. McLaren, and the results (not yet published) in chronic gonorrhoea appeared to be very satisfactory. Possibly the mode of action in these cases was by improving drainage.

Bartholinitis

Bartholinitis may subside under local fomentations. If an abscess forms it can be incised, but a better plan in most cases is to puncture it with a hollow needle attached to a syringe, to aspirate the contents, and to inject either colloidal silver or a 1 per cent mercurochrome solution. The aspiration may have to be repeated, but it has the advantage over

incision that it allows the patient to get about and does not necessitate any local treatment at home. The same method of treatment may be applied to peri-urethral abscess. The treatment of infected Skene's tubules has been described above (see p. 28).

Salpingitis generally necessitates rest in bed, fomentations to the lower abdomen and hot douching, or more prolonged application of heat within the vagina by the Elliott applicator or by diathermy. Operative measures are rarely necessary. *Salpingitis*

In proctitis Clements and Hughes found that irrigation with acriflavine solution, 1 in 5,000, was far more effective than irrigation with potassium permanganate, whereas Brunet and Salberg recommended suppositories of 2 per cent silver protein, one being inserted after each motion and before going to bed. Recently I have found painting the lower end of the rectum and of the anal canal with a 10 per cent mercurochrome solution better than any of these methods. *Proctitis*

(4)—Tests of Cure

The determination of cure of gonorrhoea is even more difficult in women than in men. The following procedure seems to embody the best of the many methods recommended by different workers. It is assumed that treatment has been continued for some weeks after urethral and rectal discharges have been free from inflammatory products and that specimens from the cervical canal and vagina have been negative in respect of gonococci.

After suspension of treatment in cases that are still uncured gonococci may appear on the surface only intermittently and then without giving rise to any obvious signs, and it is naturally important to take specimens of cervical secretion at the times when they are most likely to be on the surface. It is well known that this is about the time of menstruation and it is usually recommended to take specimens just before or just after the period. Recent work by F. Schmidt-La Baume and by H. Wendeborn has shown, however, that if specimens are taken during the period (on the second or third day) a substantially higher percentage of positive results will follow than when they are taken just before or just after it. *Influence of menstruation on secretion*

At the first sitting, besides taking specimens for microscopical examination and culture, it is a good plan, as in the case of men, to take blood for the gonococcal complement-fixation test. Specimens for microscopical and cultural tests should be taken from the urethra, cervical canal, posterior fornix, and rectum; and for the cultures plates are much better than tubes. Much depends on the care and thoroughness with which the specimens are taken, especially for the cultural test. It should be remembered that in most cases at this stage gonococci are very scanty, and a perfunctory rub of the platinum loop or the cotton-wool swab over the surface may easily result in a negative finding, whereas a careful spreading of secretion (with the loop or the swab repeatedly recharged) in such a way as to make use of the whole area of *Collection of specimens*

culture medium may result in the appearance of a few colonies of gonococci.

The gonococcal complement-fixation reaction should be negative, and slides and cultures should show the absence of gonococci, and the urethral and rectal specimens should show the absence of pus cells, before a provisional opinion is given that probably the infection has been eradicated. Then after an interval of three months it is a good plan to repeat the tests at three successive menstrual periods.

*Complement-
fixation
reaction*

The chief difficulties in pronouncing a cure arise when the blood reaction, having been found positive at the first sitting, does not diminish in strength, especially when there is a persistent cervicitis. In such a case the only thing to be done is to double or treble the tests, sometimes trying the effect of introducing an irritant, such as Lugol's iodine solution, into the canal and taking specimens the following day. If these additional efforts to unearth the gonococcus still fail, my own view is that the patient can safely be regarded as non-infectious.

7.—VULVOVAGINITIS IN CHILDREN

(1)—Clinical Picture

578.] In an acute attack the vulva is considerably reddened and tender, and greenish-yellow discharge pours from the vagina. The soreness may be so great that the child is reasonably comfortable only when her legs are held wide apart and a cooling lotion is kept applied to the labia. Soon, however, the acuteness of the inflammation dies down, and the discharge become only slight and muco-purulent. After a further period it may disappear, to reappear intermittently in a way which causes all who are experienced in the vagaries of this disease to be very cautious over pronouncement of cure. In most cases the disease does not reach higher than the vagina, but in a very small proportion it has been known to cause pelvic complications and even fatal peritonitis. Proctitis is common, but metastatic complications seem to be rare.

(2)—Course and Prognosis

The course of the disease is usually prolonged. D. Kathleen Brown found in 46 cases attending to completion of treatment at Guy's Hospital that the average duration was 67 weeks, with a minimum of 17 and a maximum of 204. At the Children's Home for this disease at Waddon, Surrey, the average duration of residence of 35 cases discharged as cured was 31 weeks, which included 8 weeks under observation after suspension of treatment. These figures may suffice to show the need for caution in prognosis respecting the duration of an attack of gonococcal vulvovaginitis.

(3)—Diagnosis

By no means all cases of vulvovaginitis in children are gonococcal. Brown found in a series of 292 cases that the ratio of gonococcal to non-gonococcal was 1 to 1.5. In the non-gonococcal the infecting organisms in most cases were streptococci, staphylococci, *B. coli*, and diphtheria bacilli; dirt and threadworms also were responsible in some instances. A. C. Ruys in an elaborate bacteriological research of 161 cases found only 28 to be gonococcal. In twelve with severe purulent discharge influenza bacilli were isolated, and in a number of others the cause was traced to foreign bodies. Probably the percentage of gonococcal cases in this series was lower than the average (Brunet and colleagues found 79 per cent of 241 cases to be gonococcal), but the figures show the need for careful bacteriological tests before a diagnosis is made.

(4)—Treatment

The intractability of this complaint and the distress and trouble to *Prophylaxis* which it gives rise justify very great care over its prevention. All adult women suffering from gonorrhoea and having the care of children should be instructed most carefully to cleanse their hands after attending to themselves and before attending to any child. Needless to say, no female child should be allowed to sleep in the same bed with anyone suffering from gonorrhoea, and all toilet articles used by the latter should be kept strictly separate. In institutions in which female children are housed it is a mistake to rely only on inspection on admission and negative bacteriological tests; in this way many institutions have been caught out by epidemics of vulvovaginitis. The only safety lies in a regime based on the principle that every child is possibly a gonococcus carrier and therefore a danger to other children through its towels and any article which may come into contact with its ano-genital area. Such articles should be kept rigidly separate, and temperatures should not be taken anywhere in that part of the body.

While the inflammation of the vulva is severe and the parts are very *Curative* tender, attempts should not be made to apply any local treatment other than sitz baths for the sake of cleanliness and perhaps cooling lotions as the child lies in bed with the legs apart. Later, when the inflammation has died down, the practitioner is faced with the difficulty of choosing from a multitude of remedies which have been recommended by different authors, and it is possible here to state only the principles on which to choose the method. Whatever local application is made to the vagina ought to reach the vault, since it is useless to apply remedies to the lower half of the canal, leaving the gonococcus to flourish in the upper half. When the discharge is acute, the simplest plan is to douche the vagina through a soft catheter passed gently as far up as it will go. The lotions can be any of those recommended for douching in gonorrhoea of adults. After douching it may be useful to introduce some silver

preparation in a form likely to stick to the wall of the vagina, e.g. 10 per cent silver protein (protargol) in glycerin, introduced on a Playfair probe.

Menulas tubes

A very convenient method of introducing remedies into the vagina with or without previous douching is by Menulas tubes. These are glass tubes so arranged that by removing a cork at one end, applying a rubber bulb to the other, and passing the open end well up into the vagina the contents can be expelled very easily in such a way that the medicament reaches every part of the vagina. Various mixtures are supplied in the tubes, those used by myself with good effect being the 'lactic acid' and the 'glucose' applications. Both contain lactic, acetic, boric, and tartaric acids with aluminium acetate and glycerin, while the 'glucose' formula contains in addition 5 per cent glucose. The medicament is in a form which insures prolonged action.

Painting of cervix and vagina

Another method which is often successful is to pass a large endoscope tube as if for urethroscopy and to paint the cervix and vault of the vagina with 10 per cent mercurochrome solution. In carrying out this treatment, which is done twice weekly, it is important to verify by inspection that the whole surface has been painted, because large sections can easily be missed.

Brunet and his colleagues trained the parents of their patients to pass an endoscope tube daily and to syringe 2 per cent mercurochrome solution against the cervix.

Urethra

Many workers leave the urethra alone, but at the Waddon Home it is painted daily with one of several remedies applied on an orange-stick. The drugs used are such as 5 to 10 per cent mercurochrome solution; 10 per cent protargol in glycerin; neo-reargon, dry; acriflavine, 1 in 1,000 to 1 in 500; acriflavine bougies.

Vaccines

On the use of vaccines opinions differ here as much as in gonorrhoea of adults, but the same principles seem to be applicable (see p. 17).

Oestrin

Recently a number of workers have claimed good results from injection of the hormone oestrin, on the principle that it stimulates the development of an adult type of mucous membrane in the vagina, and this is supposed to resist invasion by the gonococcus. D. Nabarro and A. G. Signy (1935) obtained the best results with 1,000 to 2,000 international units injected daily, or an initial dose of 10,000 units by injection followed by a daily dose of 4,000 units by mouth; later they found that injection of oestrin was unnecessary, equally satisfactory results following the oral administration of from 4,000 to 6,000 units a day from the start. Other workers do not appear to have seen good effects from this form of treatment. It goes without saying that attention to the general health is of the greatest importance in the management of this very troublesome complaint.

Rectum

Rectal gonorrhoea should be treated on the same principles as in the adult (see p. 31).

(5)—Tests of Cure

Tests of cure carried out after suspension of all treatment require cultural and microscopical examination of a number of sets of specimens from the vagina, urethra, and rectum. At least three sets taken at intervals of a week should be quite negative before the child is sent away on probation for three months, when another set should be taken. If these are negative, another period of probation to be followed by a final test should be recommended.

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GOUNDOU

See YAWS

GOUT

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Reference may also be made to the following titles:

ARTHRITIS	FIBROSITIS
ECZEMA	METABOLISM
SCIATICA	

1.—DEFINITION

579.] Gout is characterized by acute, subacute, or chronic outbreaks, inflammatory or allergic in nature, affecting connective tissues, especially articular cartilages, and associated with disordered metabolism most obviously shown by an abnormally high level of uric acid in the blood. The uric acid in the form of sodium biurate tends to be deposited in tissues which have been in any way damaged and which therefore have a lowered *pH*, commonly described as increased acidity. Such deposits are most frequent in the cartilage of the joints or ear and, though at first microscopical, they sometimes attain a large size in the hands and feet. These deposits or tophi are popularly termed 'chalk stones', because they tend to ulcerate through the skin and discharge a

white chalky material which is composed of needle-shaped crystals of sodium biurate with sometimes a small proportion of calcium phosphate or carbonate.

2.—AETIOLOGY

<i>Sex and age incidence</i>	Gout is much more common in males than in females and is very rare in women before the menopause. Though exceptional cases have been recorded in early infancy, it seldom occurs before the age of twenty, and then is related to a strong gouty inheritance. The first attack most frequently occurs between the ages of thirty-five and fifty.
<i>Heredity</i>	Hereditary influences are present in between 50 and 75 per cent of the cases; the mother may transmit the condition without being obviously affected.
<i>Occupation</i>	Some occupations conduce to gout, notably those providing opportunity for habitual consumption of alcoholic liquors of the heavier kinds: thus there is a high incidence among inn-keepers, brewers' draymen, butlers, and cellarmen. It is also common among those who eat a large amount of meat, for example butchers, and possibly a related fact—has been reported as a result of liver therapy in anaemia.
<i>Liver therapy</i>	Those whose work entails the risk of plumbism are also liable to be attacked, for example painters, plumbers, and compositors.
<i>Alcohol</i>	The influence of alcoholic liquors varies, burgundy, champagne, port, beer, and stout being more liable to cause gout than the lighter wines and spirits.
<i>Injury</i>	Injury may precipitate an attack in a gouty subject, and recently American authors have called attention to the incidence of gout after surgical operations.
<i>Seasonal incidence</i>	The majority of attacks, particularly the earlier ones, occur in the spring; as the disease becomes established a second attack in the autumn frequently occurs, and in the later stages attacks may occur at any time, though more often in winter than in summer.
<i>Exercise</i>	Strenuous exercise is often the cause of an acute attack owing to the excessive production of endogenous uric acid as a result of muscle metabolism (see below).

3.—PATHOLOGY

<i>Exogenous and endogenous uric acid</i>	The generally accepted view is that gout is a disturbance of purine metabolism marked by excess of uric acid in the blood and its deposition in the tissues. Purine bodies are derived from the nucleo-proteins, which are constituents of the nuclei of cells. Meat extracts and glandular substances, such as pancreas (sweetbread), liver, and brains, are rich in purine bodies, but eggs are free and milk nearly so. The purine bodies in the food are the source of what is termed exogenous uric acid, but on a purine-free diet uric acid will still be present in the blood, being
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derived from the metabolism of muscles and the breakdown of leucocytes and other tissues. This is termed endogenous uric acid.

The nucleo-proteins of the food are changed in the course of digestion into nucleosides, which are conveyed to the liver by the portal vein and there converted by the action of an enzyme into amido-purines. These undergo further change into oxy-purines, xanthine, and hypoxanthine, which may in turn be broken down into uric acid. Only a fraction of the ingested purines appears in the urine as uric acid; of the remainder some may be changed into simpler substances by bacterial action in the intestine and by the liver. It is probable that urea rather than uric acid is the chief end-product of purine metabolism. Any disorder of digestion may lead to the absorption of unchanged purines in quantity beyond the capacity of the liver to metabolize completely. Purine metabolism is readily disturbed, and disturbances leading to excessive formation of uric acid may be due to indiscretions in diet, abuse of alcohol, fatigue, unaccustomed exercise, and other factors generally regarded as liable to cause gout.

*Purine
metabolism*

The amount of uric acid in the blood of normal persons varies between 2 and 3.5 mgm. per 100 c.c., of which about 2 mgm. are endogenous. The figures show slight variation according to the method of analysis used, but that of Folin (1933) is now generally accepted as the standard. The saturation point is slightly over 10 mgm. per 100 c.c., a level which is rarely reached in gout though met with in leukaemia, eczema, some febrile conditions, and some forms of nephritis. On a purine-free diet the amount is generally about 2 mgm. per 100 c.c.; more than 3.5 mgm. in women and 3.7 mgm. in men should be regarded as abnormal and suggestive of gout. A lower level may occasionally be found even in acute attacks and is not uncommon between attacks in the early stages of the disease.

*Blood
uric acid*

There is a close relation between the excretion of uric acid and phosphoric acid, both being products of nuclear metabolism; this may, however, be varied by the mobilization of uric acid which has been stored in the tissues.

*Uric acid and
phosphoric
acid*

Uric acid is generally present in the blood in organic combination with thyminic acid and in this form is apparently excreted much more easily than when combined with sodium in the form of sodium biurate. It is in this form that it is deposited in the tissues.

The fact that the proportion of uric acid in the blood may be much higher in leukaemia and other diseases than is usual in gout indicates that increased formation of uric acid is not the only aetiological factor in gout. The view that failure in the functions of the kidney of a specific kind plays a part is generally accepted. It has been shown that the rate of excretion of uric acid in gouty patients is below that of ordinary individuals on the same diet. Garrod demonstrated that in many cases the average daily excretion of uric acid by gouty subjects between the attacks was less than normal, which he regarded as 8 grains a day, and was frequently far below this figure. Even during the early stage of

*Excretion of
uric acid*

acute attacks, when the urine was loaded with urates, the average excretion of uric acid was less than normal but tended to increase as the attack subsided.

Other less understood factors play a part, for the level of uric acid in the blood may be high without exciting an attack; one person may have a level of 4 mgm. per 100 c.c. and an acute attack, whereas another may have a level of 6 or 7 mgm. without any obvious discomfort; with the onset of the acute symptoms the level falls, to rise again as the attack subsides.

Talbott and his co-workers have demonstrated variations in the metabolism of water and salts immediately prior to an attack. The amount of uric acid in the blood is increased during and after an attack, and tophi may diminish in size or even disappear after a severe or prolonged attack. Jennings's work shows that uric acid is absorbed from the tissues and excreted under the action of sodium salicylate or of cinchophen. Once formed in the body uric acid does not appear to undergo further changes, but is either excreted by the kidney or deposited in the tissues, from which it may be reabsorbed and excreted.

*Source of
uric acid in
leukaemia*

In leukaemia and febrile conditions, in which hyper-uricaemia occurs, the excess of uric acid is derived from metabolic changes; in leukaemia it is derived from the breakdown of leucocytes and is therefore endogenous, whereas in gout the excess is probably purely exogenous and derived from the food. Whether this fact is of any importance it is difficult to say. The important distinction is that in gout the excess of uric acid is deposited in the tissues, whereas in the other conditions it continues to circulate in the blood until it is excreted.

*Impairment
of excretion*

Although it is obvious that an excess of uric acid from the food plays a part in the production of gout, there are two other possible factors. First, whereas in the normal subject any excess is quickly excreted, in the gouty patient the power of the kidney to excrete uric acid is certainly impaired; this is probably the essential pathological factor. It may be argued that the impairment in function is secondary to damage to the kidney caused by the need to excrete more than the normal amounts of uric acid, but the balance of evidence is in favour of the view that the defect is primary and in some cases certainly hereditary. There is some evidence that the excretion of uric acid and of other metabolites, such as urea, may be separate and distinct functions, but this as yet lacks proof. The second possibility which should be considered is that a metabolic derangement in the liver or other parts of the body may lead either to an excessive production of uric acid or to its presence in the circulation in a form which can be less readily excreted than the normal. As mentioned above, uric acid is more readily excreted in organic combination than in the form of sodium biurate.

*Deposition
of urates in
tissues*

To explain the deposition in the tissues, which is the characteristic feature of gout, Ebstein's hypothesis has been generally accepted. He held that necrosis of the fibrous tissues was the primary change and

that urates were precipitated from the tissue fluids owing to a change in the pH, a lowered alkalinity, set up by these necrotic changes. Garrod found ulceration of the cartilage of the great-toe joint in 80 per cent of persons over thirty years of age who had not had gout, which may explain why this joint is so often attacked. It may further be noted that gout usually affects the parts in which the circulation is most sluggish, namely, the extremities, and also that it is at the time in the twenty-four hours when the circulation is most sluggish that the attacks typically occur.

There is some evidence that the end-products of disordered metabolism may act in a similar way to those foods which induce attacks of urticaria, asthma, and the like in susceptible subjects. This allergic effect depends upon the tissues being sensitized in such a way that an excessive reaction is produced by even minute doses of specific toxins. If such an hypothesis proves to be correct, the articular symptoms of gout would be of much the same character and induced in the same way as those of serum sickness or possibly intermittent hydrarthrosis.

On this hypothesis the connective-tissue cells, and especially those of cartilages, may have an inherited sensitivity or may be sensitized by the long-continued absorption of certain toxins, and under these conditions a dose of toxin may set up an allergic reaction with the symptoms associated with gout. In the resulting small areas of necrosis the excess uric acid in the blood is deposited, forming tophi or superficial incrustations of sodium biurate in the articular cartilages. These necrotic areas can be recognized in radiographs as clear areas or erosions in the articular ends of the bones, entering into the affected joints, especially those of the great toe and fingers. The poor blood-supply and slow rate of circulation in the cartilage are probably the most important factors in determining the site of gout, and the liability of the great toe to injury and the weight it has to bear are contributory factors. Gout is not due to the local action of an infective agent, but sodium biurate may be deposited in joints which have been damaged by bacterial action.

*Deposition
of sodium
biurate in
joints*

Sir William Roberts demonstrated that sodium salts diminished the solvent power of a fluid for sodium biurate. The solvent power of pure water is 1 in 1,000, but that of a solution of salts in the same proportion as present in blood serum is 1 in 10,000, and solutions of sodium salts, whether alkaline like the carbonate or neutral like the chloride, have the same effect. His view that uric acid was normally present in the blood as a quadriurate which became converted into the less soluble biurate by interaction with the alkaline carbonates is no longer accepted, and it is believed that uric acid in the blood is normally in organic combination, from which it is separated by the kidney. In gout a proportion of the uric acid is present as sodium biurate, which is relatively insoluble and readily thrown out of solution in the presence of salts of sodium. Potassium salts appear to retard this precipitation slightly. Synovial fluid and cartilage contain the highest proportion of sodium

*Solubility
of sodium
biurate*

salts; fibrous tissue, blood and lymph come next; and the quantity in the organs is much less. This accounts for the fact that the biurate is precipitated in the joint tissues, whereas the muscles, brain, liver, and spleen are not affected. The synovial fluid, being relatively stagnant, provides other conditions favourable to precipitation. The freer circulation of blood and lymph in other fibrous tissues favours reabsorption of uratic deposits when the proportion of uric acid in the blood is reduced by excretion. The synovial fluid has frequently been found to be laden with crystals of sodium biurate, which tend to be deposited in those parts of the joint which have been damaged by wear and tear or other form of injury.

A lowered pH (increased acidity) of the tissues also appears to favour precipitation, a fact which explains why damaged or necrotic areas are the chief sites of uratic deposits.

The deposition of crystalline sodium biurate in the tissues may take place without giving rise to any symptoms and is not the cause of acute attacks of gout. The idea that it is the mechanical effect of the crystals which causes pain has been generally abandoned. Articular cartilage may be found incrustated with uratic deposit at necropsy when there have not been any symptoms during life, and tophi frequently form in the cartilage of the ears without the patient being conscious of their presence until they attain some size.

*Lead and
gout*

The influence of chronic lead poisoning upon gout has been referred to on page 38. It is less often seen now than formerly, but in the last century the association was well marked in the south of England, though rare in the north. Oliver noted that workmen from the south developed it if they migrated to the north. Probably lead accelerated the development of gout only in those with an hereditary or acquired predisposition to the disease and most likely by interference with the renal functions.

4.—CLINICAL PICTURE

Acute attack

The classical type of acute gout is marked by sudden onset, most often in the great toe in the early attacks, later in the tarsus, ankles, knees, fingers, or wrists: the other joints are seldom attacked acutely. The affected joint is swollen, and deep red or reddish purple in colour; sometimes slight oedema is present but the tenderness is too extreme to justify testing for this; pain is severe, often excruciating, the temperature is generally a little raised, and the urine scanty and high coloured. The first attack may last only a few days; but as the disease gains a firm hold on the tissues of the victim the attacks may last several days, or one may follow another affecting different joints in turn, and this may go on for several weeks. In the absence of a definite history of previous attacks it may easily be mistaken for rheumatic fever; slight desquamation may occur over the affected joint, which is not met with in rheumatism.



Photograph and radiograph of same hand from case of advanced tophaceous gout showing extensive necrosis of bone giving place to deposits of sodium biurate. In index finger there is calcification, as shown by greater density of shadow. Clear areas are well seen at base of proximal phalanx of fifth finger and typical small erosions in middle phalangeal joint of middle finger. There is very little osteophyte formation

PLATE I

An attack often occurs when the victim feels in the best of health, but there may be vague premonitory symptoms, dyspepsia, constipation, headache, depression, and a characteristic irritability of temper: very often the attack comes on in the early hours of the morning when the circulation is sluggish. The first attack is usually followed by a period of freedom for one, two, or more years. If the warning has been heeded and the mode of life altered accordingly, many years may elapse before a fresh outbreak, which may be brought on by some other illness or an accident.

A chronic type is now more frequent than the acute form and may be confused with rheumatoid and other forms of arthritis. It is insidious in onset, attacking generally the small joints of the hands or feet, the ankles, or wrists; pain is less acute and may be very slight. The phalangeal joints when affected are often spindle-shaped or the whole digit may be slightly but uniformly swollen and often dusky red in colour. The disease progresses slowly and relentlessly with extensive deposition of uric acid in the damaged tissues, the cartilage becomes eroded, necrotic changes in the bones follow, and the joints become completely disorganized, often resulting in a knobby bulbous appearance with much distortion; successive attacks of acute gout will produce similar results (see Plate I). *Chronic form*

Tophi are among the most characteristic features of gout. They are nodular swellings formed by the deposition of sodium biurate in the tissues and are most common in the cartilage of the ear or at the margin of the joints and in ligaments, tendons, and bursae, less frequently in other tissues such as the skin and conjunctiva. They may be present in the ear without any history of an attack of arthritic gout, but more often they do not appear until the disease is well established. The skin over them is often bluish or violet, and through it the whitish chalky formation may be detected. In long-standing cases they may reach a large size and cause much deformity and crippling. The skin sometimes gives way and the tophus may be shelled out leaving only a slight scar; this most frequently occurs in the ear. When the larger ones break through in the neighbourhood of the joints, a purulent discharge loaded with crystals of the biurate follows and the resulting ulcer takes long to heal. *Tophi or chalk stones*

All nodular swellings of the terminal phalangeal joints are apt to be regarded as 'chalk' by the public but quite erroneously, since Heberden's nodes, the commonest form of such nodular swellings, are not in any way related to gout, but are a form of osteoarthritis. A radiograph will clear up any doubt, the nodules being translucent if of sodium biurate but opaque if bony. Heberden's nodes, however, are at first synovial cysts and at this stage will be translucent to X-rays.

Gout, being a general and constitutional disease, has manifestations other than articular; it may involve the connective tissues in any part of the body and give rise to the symptoms characteristic of fibrositis due to any cause; lumbago is perhaps the commonest form, and in any *Constitutional disorders*

case of persistent fibrositis an estimation of the blood uric acid may throw light on the cause and be a valuable guide to treatment.

Bursitis

Bursae, owing to their synovial content, are peculiarly liable to be the seat of gouty attacks. The precipitation of sodium biurate is favoured by the high concentration of uric acid in the synovial fluid and by its high content of sodium salts. The deposition may be associated with an acute inflammatory attack or may take place imperceptibly. The olecranon bursa is the most frequently affected and may attain a large size (see Fig. 1). It has been said that four out of five cases of olecranon

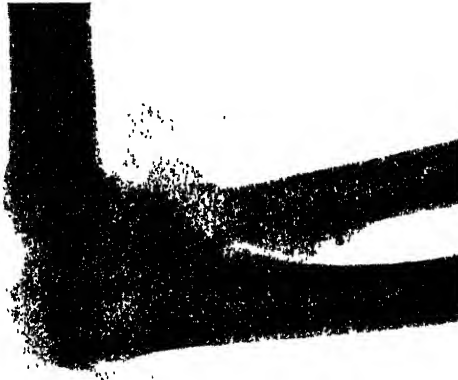


FIG. 1.—Olecranon bursitis due to gout; elbow-joint also affected and tophaceous deposits around radial tuberosity

bursitis are gouty; the tophi can usually be distinguished by sight through the thin outer coverings. The bursa which is often present over the great-toe joint, inflammation of which is the cause of the common bunion, may also be the seat of gouty inflammation, but at this site inflammation is often regarded as gout without any other evidence of the disease. Tendons and ligaments, especially

where they are bathed with synovial fluid, as in the vicinity of joints, are also often the seat of tophaceous deposits.

Associated disorders

Many constitutional disorders of metabolic origin have been attributed to gout, but it is safe to assume that in the absence of raised blood uric acid the metabolic error is of a different nature. Dermatoses often described as eczema may be associated with a gouty constitution, and high levels of blood uric acid may be found in these conditions, which therefore call for treatment on the same lines as for gout (Schamberg and Brown; Luff).

Eczema

Glycosuria

Glycosuria is occasionally found in gouty persons, but it is doubtful if it has any specific relation; Willcox laid much stress upon the fact that the removal of a focal infection in such cases is sometimes followed by disappearance of glycosuria.

Asthma

Asthma has been described as a form of irregular gout but does not present any characteristic features in the gouty. Gout in one generation has been known to be followed by asthma in the next, and gout again in the following generation, which is interesting in view of the possibility of allergy as an aetiological factor in gout. Allbutt noted the occurrence

of gout, migraine, and eczema in different members of the same family.

Disorders of digestion are common in patients subject to gout and generally take the form of heartburn with acid eructations. There is usually some degree of chronic gastric catarrh and the acidity is attributed to hyperchlorhydria, although this is by no means always present. I have found by analysis of the stomach contents after a test meal that free hydrochloric acid is usually absent in such cases and that the hyperacidity is due to organic acids—butyric, lactic, or acetic—resulting from the fermentation of food in the stomach. Falkenstein (1904) concluded that the absence of free hydrochloric acid favoured bacterial fermentation, and that in such circumstances, the nucleo-proteins in the food not being properly digested, the production of uric acid was increased. In cases of hypochlorhydria he advocated the administration of hydrochloric acid with meals both to assist digestion and to reduce the gouty tendency, and I can confirm the value of this method of treatment. Dyspepsia with hypochlorhydria is also sometimes associated with chronic fibrositis, which may itself be a form of gout.

Dyspepsia

Formerly gout was believed to affect the heart and to cause palpitation and even anginal pain, especially if an acute attack was 'suppressed'. This view is no longer held, though such symptoms may occur as a result of dyspeptic disorders associated with gout or of excessive indulgence in the pleasures of the table—popularly supposed to be the failing of the gouty man. Pericarditis may be met with in cases of gout associated with advanced nephritis but is due to uraemia and not directly to gout. Other evidences of cardiac or arterial disease which may be met with in long-standing cases of gout are not in any way different from those due to the effect of chronic hyperpiesia associated with renal disease. It is important to note that the blood-pressure, both systolic and diastolic, in the earlier stages of gout is generally low and does not become raised until the effects of reduced renal efficiency begin to show themselves. It is important to watch the blood-pressure and to guard against the developments which a rising pressure may indicate. Allbutt stated that the subjects of frank gout were not more subject to atherosclerosis than other persons of equal age, and there is certainly no definite evidence that gout exercises any morbid influence directly upon the heart and arteries.

*Diseases
of the
circulatory
system*

Paget described 'gouty phlebitis' and stated that it often occurred in different parts of the same vein at the same time and had a marked tendency to relapse; the condition has also been called 'phlebitis migrans' on account of these characters. It is not unlikely that gout may attack the outer coats of the veins as it attacks other fibrous tissues such as the nerve sheaths. Such a condition would be more likely to yield quickly and completely to anti-gout treatment than phlebitis due to other causes, and the treatment should certainly be tried in any case of phlebitis in which there is reason to suspect the presence of gout. Gouty persons are also supposed to have a proclivity to the formation of clots in the veins apart from phlebitis.

Phlebitis

Ocular diseases

Conjunctivitis and iritis have been described in gout; it is not unusual to find minute tophaceous deposits beneath the conjunctiva, even when absent elsewhere, and Garrod found deposits in the sclerotics. Glaucoma has also been attributed to gout. In all these conditions, if gout is suspected, the diagnosis should be verified by examination of the blood to ascertain if the level of uric acid is above the normal.

Renal disease

The association of gout with renal disease has long been recognized, and a form of chronic nephritis is sometimes spoken of as 'gouty kidney'. Levison held that gout could not develop unless a renal lesion were present. Luff found, among sixty-seven cases of granular kidney not known to have had gouty attacks, uratic deposits in one or more joints in thirty-one; Norman Moore gave similar figures, but the view based on these observations that gout is due to inability of the kidney to excrete all the uric acid formed in the system is insufficient to explain the problem. Allbutt noted a marked increase in the blood uric acid in some cases of nephritis without any outbreak of gout. Roberts observed that the coincidence of gout with renal disease was much more common among hospital patients than among the well-to-do, among whom even chronic gout might run its entire course without any sign of renal disease; but the absence of symptoms cannot be taken as proof that nephritis does not exist.

Gravel and calculi

Uric-acid gravel and calculi are often associated with gout, and paroxysms of gravel may alternate with the arthritic attacks. This may occur even if the actual excretion of uric acid is less than the normal, for the precipitation depends not on its concentration but on a low specific gravity and lack of pigment in the urine; these characters favour the deposition of uric acid and are frequently met with in the gouty between the arthritic attacks. This is not peculiar to gout; the so-called cayenne-pepper sediment in the urine is not uncommon and is often met with in childhood. I have known stone in the kidney in one generation followed by severe gout in the next.

Anomalous cases in young subjects

Gout occurs rarely in young people of either sex without any hereditary influence or obvious dietetic fault; it is associated with a high level of blood uric acid and the formation of tophi. These cases are probably due to some inborn error of metabolism and are resistant to treatment; two such cases have come under my notice, a young male, a lifelong teetotaller, and a hospital nurse in the thirties also an abstainer. Allbutt has recorded a case with tophi in a boy aged ten.

5.—PROGNOSIS

In uncomplicated gout the prognosis is favourable provided that the habits of life conducive to the disease are corrected, and then the victims often reach a good old age. After the first attack a long interval may occur and there may even be no recurrence. When the hereditary influence is marked, however, this can hardly be anticipated and the

usual experience is that attacks recur at yearly intervals. The strictest attention to the mode of life is essential, but in some cases, in spite of every care, the attacks become more frequent, and fresh joints are invaded and become stiffened and deformed, often with enormous tophi. Gout is rarely the actual cause of death; but the case may terminate in nephritis or arterial degeneration, or in thrombosis or embolism. Some of these events were formerly described as retrocedent gout.

6.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

The typical paroxysm of acute gout should not present any difficulty in diagnosis, but the acute form is now much less common than the subacute, recurrent, and chronic forms. Detection of a raised level of blood uric acid, which should be tested for in every doubtful case, or the presence of definite tophi in the cartilage of the ear or in the neighbourhood of the joints furnishes the only unmistakable evidence, but even here there are possible pitfalls; in rare instances tophi may be composed of calcium phosphate and free from sodium biurate, and these do not point to gout; they are opaque to X-rays and may thus be distinguished from those due to sodium biurate, but, especially in long-standing cases, calcium carbonate and phosphate may be mixed with the deposits of the biurate. High levels of blood uric acid may occur in eczema and have been regarded as evidence of a gouty origin. Even higher levels are seen in leukaemia and are then due to entirely different causes; in these conditions tophi do not form, for reasons which have been discussed on page 40.

Blood uric acid and tophi

Acute gout, especially if affecting one or more of the large joints, may be incorrectly diagnosed as rheumatic fever: relief may follow the use of salicylates in both conditions. The great toe is not invariably the first joint to be attacked in gout. The blood uric acid in the early attacks may not be raised above normal limits and tophi will not form until, it may be, years after the initial attack. A history of previous attacks of arthritis, generally of sudden onset and short duration and affecting as a rule only one joint, with complete remissions and absence of cardiac involvement, should suggest gout; sweating is more prominent in rheumatism. Careful inquiry into the family history is necessary in view of the importance of heredity in gout.

Diagnosis from rheumatic fever

Rheumatoid arthritis may be closely simulated, especially by gout affecting one or more of the phalangeal joints; the X-ray appearances may be a guide, but clear areas and sharply outlined erosions at the margins of the joint occur in both conditions; a more important distinction is that rarefaction of the bones is more marked and extensive in rheumatoid arthritis.

From rheumatoid arthritis

Gonorrhoeal arthritis of one joint may simulate gout closely, and diagnosis will depend on discovery of the cause.

From gonorrhoeal arthritis

Gout may be the precursor of osteoarthritic changes, especially in the

*Gout and
osteo-
arthritis*

*Diagnosis
from bursitis*

*From chronic
villous
synovitis*

fingers, knees, and hips or may supervene upon such changes already existing from other causes.

Inflamed bunions are often mistaken for gout, but careful examination should make the diagnosis clear; an investigation of the blood uric acid will help.

Chronic villous synovitis of the knee-joints of women in middle life, usually of endocrine origin, may be due to gout or at least associated with a relatively high blood uric acid. By the usual methods of estimation, anything above 3.5 mgm. per 100 c.c. is high in women, although in men the normal limit may be slightly higher.

7.—TREATMENT

(1)—General and Spa Treatment

Drugs

For the acute paroxysm there is still no remedy to compare with colchicum. There are many favourite prescriptions and forms of administration and it is the basis of many of the proprietary medicines and 'gout' pills. The following is a useful formula but may be modified as desired:

Colchicum wine	—	—	—	—	15 minims
Sodium salicylate	—	—	—	—	15 grains
Potassium bicarbonate	—	—	—	—	30 grains
Peppermint water	—	—	—		to 1 fl. ounce

This dose should be given every 2 hours for two or three doses; with successive doses the interval should be increased to 3, 4, and 6 hours, and continued three or four times a day until the attack has subsided. Blue pill followed by a saline aperient in the morning is desirable at the outset. In long-standing cases potassium iodide 5 grains may be added to the colchicum mixture and the sodium salicylate reduced or omitted; magnesium sulphate is a useful addition in some cases, especially in constipated or plethoric patients.

In the chronic and irregular forms of gout, and particularly for relief of the neuralgic pains which are sometimes due to fibrositis of gouty origin, a pill containing colchicine is convenient, such as the following:

Colchicine (or colchicine salicylate)	—	—	—	—	$\frac{1}{100}$ to $\frac{1}{80}$ grain
Extract of nux vomica	—	—	—	—	$\frac{1}{4}$ grain
Extract of hyoscyamus	—	—	—	—	$\frac{1}{2}$ grain
Extract of chamomile	—	—	—	—	1 grain

for 1 pill.

Dose: one pill three times a day after meals for 2 or 3 weeks.

One of the effects of sodium salicylate or aspirin, which may be useful in milder cases as an alternative to colchicum, is to reduce the level of blood uric acid, and this must be remembered when testing. In 100 consecutive cases of clinical gout in which the blood uric acid was

estimated only three showed a normal or subnormal level, and inquiry revealed that in two of these uric acid eliminants had recently been taken.

Cinchophen and its modifications are among the most potent drugs for the elimination of uric acid. They must, however, be regarded as dangerous, cases of serious and fatal disease of the liver having been recorded from their use even in small amounts; the recognition of these effects is largely the result of Reichle's work. When, however, colchicum seems ineffective or there are objections to its use on any ground, cinchophen may be tried, a dose of $7\frac{1}{2}$ grains three times a day being given for two or three days followed by an interval twice as long; the drug, administered in a tablet or cachet, should be followed with half a tumbler of water in which 20 or 30 grains of sodium bicarbonate or potassium bicarbonate have been dissolved. The addition of glucose appears to lessen the risk of toxic action on the liver. Recent work by Jennings appears to indicate that sodium salicylate is quite as effective as cinchophen and free from its drawbacks. (See also LIVER DISEASES.)

For the relief of the inflamed joints the most useful local application is kaolin poultice (antiphlogistine) which should be applied in a thick layer and changed every 24 hours or more often. *Anti-phlogistine*

A hot bath for the affected limb containing about half a pound of washing soda to a gallon often gives relief. Washing soda may also be used in a lotion with belladonna or opium; the joint should be swathed in cotton-wool or absorbent gauze with an outer layer of oil silk or jaconet; the lotion is mixed with an equal quantity of hot water and poured gently on to the gauze, repeating as often as necessary to keep it wet. The following is a useful formula, sodium bicarbonate being less irritating to the skin than sodium carbonate: *Hot baths*

Sodium bicarbonate	-	-	-	- 180 grains
Tincture of opium	-	-	-	- 1 fl. ounce
Liniment of belladonna	-	-	-	- 2 fl. ounces
Distilled water	-	-	-	- to 8 fl. ounces

In spite of treatment on these lines attacks may follow rapidly one upon another with intervals of only a few days perhaps for two or three months, and in such cases spa treatment holds out the best prospect of relief if a suitable mineral water is chosen (see pp. 594, 596, and 597). For the treatment of gout it is obvious that the drinking of an appropriate mineral water will be of more importance than its external application. The choice of a spa will, therefore, be made from two aspects. In the plethoric and possibly constipated patient with a sluggish hepatic function, the waters possessing a mild purgative effect due to sulphur or sulphates will present advantages, for example those of Harrogate, Llandrindod, and Strathpeffer. Many of these, however, contain a substantial amount of sodium chloride, which Luff regarded as contra-indicated in gout, and Roberts held that gouty persons should avoid springs the activity of which is due to the presence of sodium *Spa treatment*

salts. In other cases in which the excess of uric acid is due to inefficiency of renal rather than of intestinal or hepatic function, the diuretic waters of low mineralization, such as those of Buxton or Bath, are preferable and are perhaps more generally useful in gout except in the plethoric type. In gouty fibrositis the external use of mineral waters by douching, massage, and packs is of considerable value. Whether at spas or elsewhere the free action of the skin should be promoted by the use of vapour, Turkish, or hot-air baths.

*General
hygiene*

Between the attacks, which in many cases occur only in the spring months, much may be done by attention to a proper regime. Regular action of the bowels is of great importance, but should be secured by diet and exercise rather than by laxative drugs. At the same time a periodical blue pill or dose of calomel every two or three weeks is beneficial and should be followed by a saline purge in the morning. An ample amount of water should be taken habitually, and half a pint or more, hot or cold, should be drunk on rising. To this may be added when necessary a small amount, not more than 20 or 30 grains, of a saline, such as magnesium sulphate. Weak tea may be taken instead of water if preferred but without sugar or milk. A popular custom is to add Epsom salts, as much as will lie on a sixpence, to the morning tea: a mixture of sulphates is sometimes better than the single one, and there are many preparations on the market to choose from. The habitual use of alkalis has often been advocated as a means of preventing gout, but Roberts stated that he gave potassium bicarbonate and potassium citrate repeatedly for as long as three or four years and in doses sufficient to keep the urine alkaline, and yet the arthritic attacks recurred with apparently unabated regularity. Lithium salts, piperazine and thymine acid have been extensively used, but it is improbable that they exert any solvent effect on uric acid in the body, and the reason for their beneficial action must be sought in some other direction. Many patients are convinced of their value from their own experience.

Exercise

Exercise is important and should be systematic but moderate. The man living a sedentary life in a busy office or commercial house who takes his exercise in the form of two or three rounds of golf on Saturday and perhaps Sunday as well may find the products of muscular metabolism thus induced more than his organs can deal with, and his gout will be increased rather than diminished; moreover, the gratification of the hunger and thirst induced by exercise on such lines may play a part in neutralizing otherwise beneficial effects.

(2)—Diet

On the subject of diet the popular view is to avoid red meat and alcohol, but this is a very rough and ready plan and by no means always sound. A reasonable reduction all round is a good rule for all who are getting on in middle life.

Meat

The glandular organs, liver, kidneys, and sweetbreads, should be avoided; meat soups and meat that has been twice cooked or prepared

with rich gravies, seasonings, and other accompaniments should also be forbidden. Meat may otherwise be taken in moderation; there is no reason for preferring white meat to red except that it is usually more digestible, but this is not invariably the case.

Recently Lockie and Hubbard published an investigation into four cases of gout in which the inclusion of a high proportion of fat in the diet increased the severity, duration, and frequency of attacks, whereas a restriction of fat and increase of carbohydrate appeared to make the attacks clear up more rapidly. This observation is of great importance; a diet based on Lockie and Hubbard's findings may be prescribed with advantage and at least with the assurance that it can have no harmful effect. *Fat and carbohydrate*

Meat should not be taken at more than one meal, and a meatless day once a week is advisable. Milk, butter, eggs, and cheese, in moderate amounts, are free from objection.

Fish is not so innocuous as is often supposed; plaice, sole, and whiting are generally safe, and other white fish may be taken in moderation, but herrings, salmon, other fat fish, and shellfish, with the exception of oysters, should be avoided. *Fish*

An ample supply of green vegetables should be taken, and when possible a proportion of them should be eaten raw in the form of salads: the old prejudice against root vegetables, including potatoes, is unjustifiable, for they are definitely beneficial. The same applies to fruits, though idiosyncrasy must be taken into account; strawberries provoke an allergic reaction in some people, others find them beneficial; the same also holds good for other fruits. If citrus fruits suit the individual, lemon squash and orangeade are among the best beverages for daily use. *Vegetables and fruits*

On account of the influence of sodium salts in lessening the solvent power of the serum for sodium biurate, common salt should be limited to the amount used in cooking; if it is thought necessary one of the substitutes may be employed for table use. *Salt*

Alcohol should be avoided by most sufferers from gout, and it must be left to the experience of the practitioner to decide what exceptions, if any, may be made. Beers definitely produce gout, though an occasional glass of light lager may be taken with impunity. Of wines, burgundy, champagne, and port are the most dangerous to the gouty and should all be prohibited. The light wines are tolerated by some, but not by all; a sound claret is perhaps the safest, and if taken in the continental fashion, diluted with a feebly alkaline mineral water, one glass of claret, dry Graves, or Moselle may generally be taken without harm. Spirits are by no means so free from harm as is popularly supposed and should be allowed only if really required; some patients find that gin suits them better than whisky. Tea and cocoa are free from objection; so is coffee in moderation, but overmuch black coffee should be avoided. The fact that caffeine and theobromine are purine bases led to their being regarded as sources of uric acid, but they are methyl purines which are *Alcohol*

not converted into uric acid in the body. Not less than three pints of fluid should be taken in the day, and most of this should be water, weak tea, lemonade, and the like.

(3)—Treatment of Retrocedent Gout and Special Conditions

Retrocedent or metastatic gout was frequently described in the past, but is now rarely diagnosed. The term was applied to attacks of severe pain and vomiting, sometimes to faintness occurring during an acute attack of the ordinary type, especially if the patient was exposed to cold, generally or locally: the attacks were believed to be due to congestion of the internal organs. Cerebral congestion and often apoplexy were attributed to the same cause. The treatment of such conditions must be carried out on lines appropriate to the symptoms; the treatment suitable for acute gout is seldom indicated.

The treatment of gouty fibrositis, neuritis, sciatica, and phlebitis is described under the appropriate titles. It must be carried out with due regard to the general principles described above.

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GRAIN ITCH

See BITES AND STINGS, Vol. II, p. 347; *and* SKIN AFFECTIONS
DUE TO INSECTS AND ACARINES

GRANULOMA ANNULARE

See SKIN TUMOURS

GRANULOMA, ULCERATIVE

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Reference may also be made to the following titles:

CHANCROID LYMPHOGRANULOMA INGUINALE

1.—DEFINITION

(*Synonyms*.—Granuloma venereum; granuloma inguinale; ulcerating granuloma of the pudenda; tropical granuloma; chronic venereal sores; ser-piginous ulceration of the groins)

580.] Ulcerative granuloma is a mildly infective disease of venereal origin, characterized by granulomatous ulceration of the genito-ingui-nal regions, chronic and progressive in its course without any tendency to spontaneous healing.

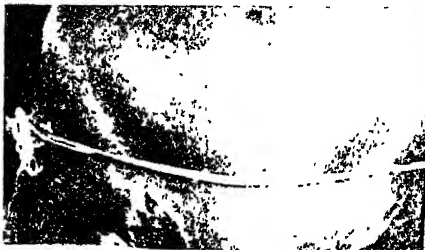
2.—AETIOLOGY

<i>Geographical distribution</i>	It is a disease of the tropical and subtropical regions of the world. It is endemic in southern India, southern China, northern Australia, North and South Africa, countries of South and Central America, and the southern States of North America. De Vogel reported an epidemic
<i>Incidence</i>	prevalence of this disease in Dutch New Guinea. The coloured races
<i>Race</i>	of the world seem to be more susceptible than the white. The greatest
<i>Age</i>	incidence of the disease occurs during the period of early adult life and middle age, although its occurrence has been reported in a few sexually


inactive children. The disease is slightly commoner in women than in *Sex* men.

In the majority of cases the disease is acquired by sexual contact. *Mode of*
Extragenital infections occur as in syphilis ~~considerable amount~~ *transmission*

The aetiology of the diseasents are thin and anaemic. in *Donovan's organisms*
intracellular organisms in thommoner in women than in men. It is chad
lesion, first reported by Doexcessive formation of hard fibrous tissed
by others, appears to havecome sequestered by the rapid formation ill,
and Baskara Menon among ns
in culture, but there does ne
regarding the nature of these
oculation of these organism re-
not succeeded in reproducin-
as



3.-MO

Histological examination of  is a small-celled infiltration of the upper part of the corium and of the papillae, with elongation of the interpapillary epidermal processes. Blood-vessels are abundant. In the older lesions there is much formation of fibrous tissue. Suppuration, caseation, and giant-cell formation are absent. Donovan organisms may be seen in clusters inside the endothelial and mononuclear cells.

4.—CLINICAL PICTURE, COURSE, AND PROGNOSIS

The incubation period is stated to vary from two to eight days. In the *Incubation* large majority of male patients there appears to be an initial genital



FIG. 2.—(a) Ulcerative granuloma of both groins; (b) nodular type of ulcerative granuloma which has spread from penis to groin

lesion. This primary lesion is usually single, indolent, and not indurated, and consists of a granulomatous base and a slightly elevated edge. In women it is difficult to observe or elicit the history of a primary lesion.

The sore may behave in one of several ways. It may heal spontaneously

and break down again into a typical granuloma. On the other hand, it may gradually develop into a spreading granulomatous ulcer (see Fig. 2).

Very often, after a circumcision has been performed on account of the persistence of the sore, a granuloma develops in the circumcision wound.

Whatever the mode of onset the fully developed granuloma is easily recognized. The disease has a predilection for warm and moist surfaces, the commoner sites being the penis, groin, inguinoscrotal folds, and scrotum in the male; the crura of the clitoris, labia, fourchette, and vagina in the female; the perineal and

Granuloma

GRANULOMA				
BY R. V. RAJAM, M.B., M.S., MEDICAL OFFICER TO VENEREAL DISEASE GOVERNMENT GENERAL HOSPITAL				
DEFINITION	-	-	-	-
ETIOLOGY	-	-	-	-
ORBITAL ANATOMY	-	-	-	-
CLINICAL PICTURE, COURSE, AND DIAGNOSIS AND DIFFERENTIAL				

FIG. 3.—Granuloma of vulva, perineum, and perianal regions

Spread

perianal regions in both sexes (see Fig. 3). The disease spreads through contiguous tissue and by auto-inoculation of opposing surfaces. In about 4 per cent of my cases the mucous membrane of the mouth was affected in addition to the genital and groin lesions (see Fig. 4). The disease spreads very slowly, taking years to cover a large area (see Fig. 5). There is a partial attempt at healing, but the scar tends to break down again.

Three clinical types of the disease may be recognized:

*Nodular
dry type*

(i) The nodular dry type is the commonest both in men and women. It is characterized by a painless granulomatous area raised above the general level of the surrounding skin, studded with nodular, sometimes papillomatous, dry granulations with an irregular or serpiginous outline.



FIG. 4.—Granuloma involving lips and cheek. This patient had healed lesions in genito-inguinal region

(ii) The *ulcus molle* type is commoner in women than in men. The ulcer is large and spreading, with a depressed base, thin edges, and a glazed moist pale-red surface almost devoid of granulations. This type is very painful and is accompanied by a considerable amount of offensive discharge. The patients are thin and anaemic.

(iii) The *sclerotic type* is commoner in women than in men. It is characterized by the early and excessive formation of hard fibrous tissue. Islands of active disease become sequestered by the rapid formation of fibrous tissues, and breaking down of the scars is frequent. In the male the penis may become deformed, contracted, and sometimes buried in the scrotum. In the female pseudo-elephantiasis of the clitoris and labia is fairly common. The vagina may become stenosed or obliterated. The urethra, bladder, cervix, and rectum are never involved, even in long-standing cases; but healing of a granuloma of the vestibule or of the perianal region may result in stenosis of the urinary meatus or of the anal orifice respectively. The lymphatic glands are not involved. In the majority of cases the general health is unaffected, but in a few long-standing cases, especially in women, a severe degree of anaemia may develop. The duration of the disease varied from two months to twenty-one years in my series of 350 cases.



FIG. 5.—Granuloma of 10 years' duration with pseudo-elephantiasis of penis, which is turned downwards and backwards towards the perineum

The prognosis is good as regards life. In early cases a cure can be assured with injections of antimony compounds. In chronic resistant cases the patient may develop a secondary anaemia which may cause death.

5.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

This depends upon the presence of the characteristic granulomatous ulceration with slow development and chronic course, occurring predominantly in the warm and moist areas of the genito-inguino-anal

- regions in both sexes; upon the constant demonstration of the Donovan organisms from the exudate; and upon the therapeutic response to antimony compounds. The Wassermann reaction is negative. Ulcerative granuloma may, however, be wrongly diagnosed as one of several conditions occurring in the same site.
- Differential diagnosis*
- From syphilis* The gummatous ulcers in tertiary syphilis have a characteristic punched-out appearance. The diagnosis is confirmed by a history of primary and secondary syphilis, a positive Wassermann reaction, and a favourable response to antisyphilitic treatment.
- From ulcus molle* Ulcus molle is an acute painful affection. The regional inguinal glands are enlarged, with a tendency to suppuration. Ducey's streptobacillus can be demonstrated from the scrapings taken deep from the edge of the ulcer. The intradermal test with dmecos antigen is positive.
- From lymphogranuloma inguinale* Lymphogranuloma inguinale is an affection primarily involving the lymphatic glands of the groin and iliac region, characterized by the development of multiple fistulae, and associated with constitutional disturbance, malaise, fever, and arthralgias. The genito-ano-rectal syndrome of lymphogranuloma may easily be wrongly diagnosed as ulcerating granuloma. Involvement of the rectum, perirectal infiltration, rectal stricture, and a positive Frei's intradermal reaction will distinguish the former from the latter.
- From malignant ulceration* Malignant ulceration of the genitalia and the groins is diagnosed by the age of the patient, the stony hard nature of the malignant growth, the rapid spread, the histological picture, and the absence of response to antimony compounds.

6.—TREATMENT

- Prophylaxis* As the disease is considered by the majority of observers to be venereal, prophylaxis consists in abstinence from irregular sexual unions, especially in tropical and subtropical regions.
- Specific* The specific action of antimony compounds has been recognized ever since Aragao and Vianna introduced the intravenous injection of sodium antimonyltartrate in 1913. Later, several aromatic pentavalent antimony compounds, e.g. stibosan (von Heyden 471), stibenyl (sodium *p*-acetylaminophenylstibinate), urea stibamine (a preparation of urea and *p*-aminophenylstibinic acid), were tried in the treatment of this disease and reported to be superior to potassium antimonyltartrate (tartar emetic) solution. Stibosan and stibenyl have been superseded by neo-stibosan (diethylamine-*p*-aminophenylstibinate). Williamson and his colleagues reported in 1933 excellent results with the trivalent aromatic compound of antimony, fouadin, and these observations have been confirmed (Rajam, 1934). As in the case of organic arsenicals in the treatment of syphilis, it appears that the trivalent antimony compound is therapeutically more effective than the pentavalent series in this disease.
- Fouadin*

The advantages of fouadin over other preparations are as follows:

(i) the drug is in a ready-made stabilized solution for direct use from the bottle; (ii) it may be injected intramuscularly without causing pain; (iii) the injections can be given at frequent intervals and even daily; (iv) immediate after-effects are not observed; (v) the late effects are negligible; the commonest complaint is joint pain, which is temporary and indicates smaller doses; occasionally a mild jaundice may develop, which clears up with cessation of treatment; and (vi) the lesions heal rapidly; hence the duration of treatment is shorter than with other compounds.

On account of the great tendency of the lesions to break down the treatment should be continued far beyond the period of initial healing. A minimum of three to four courses of injections, separated by short intervals of rest from treatment, should be instituted. A series of 12 to 18 injections of foudadin, starting with 1.5 c.c. and increasing to a maximum of 5 c.c., given on alternate days, constitutes a course. *Length of treatment*

In a small percentage of cases the disease recurs in spite of or during treatment and becomes resistant to any form of antimony. Different kinds of protein shock therapy (T.A.B. vaccine, dmelcos), X-ray exposures, radium, and diathermy have been tried in these resistant cases with varying degrees of success. *Other forms of therapy*

Any mild antiseptic dressing may be applied to the granulomatous lesions. *Local*

Patients who are run-down and anaemic from long-standing disease require treatment in hospital, nourishing food, and tonics. *General*

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GRAVES'S DISEASE

See GOITRE AND OTHER DISEASES OF THE THYROID GLAND,
Vol. V, p. 606

GROCER'S ITCH

See BITES AND STINGS, Vol. II, p. 347; *and* SKIN,
OCCUPATIONAL DISEASES

GUINEA-WORM DISEASE

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Reference may also be made to the following title:

FILARIASIS

1.—DEFINITION AND AETIOLOGY

(*Synonym.*—Dracontiasis)

581.] Guinea-worm disease or dracontiasis is met with in certain tropical and subtropical parts of Asia, Africa, and South America. The disease is not evenly distributed over these continents, but occurs in patches

*Geographical
distribution*

among groups of primitive people who are careless or indifferent in regard to the purity of the water they drink. Sporadic cases of the disease crop up in other parts of the world, but these have in most instances been imported from endemic centres.

The symptoms associated with the disease arise during the parturition of the female worm, *Dracunculus medinensis*. This long thin worm, measuring about two and a half to three feet in length and about one-sixteenth of an inch in diameter, is a parasite which lives chiefly in the subcutaneous tissues of infected persons. It has been known from very early times and was probably the fiery serpent which afflicted the Children of Israel in the wilderness.

*Classification
of worm*

The worm is a member of the superfamily Filarioidea (Weinland, 1858; Stiles, 1907). It has recently been separated from other filarial worms and placed in the family Fulleborniidae (Faust, 1930), Leiper having re-named it *Fullebornius medinensis* (1926).

*The
parturition
of the
guinea-worm*

When the female guinea-worm has reached maturity it takes up a position near the surface of the body of the infected person with its head directed towards the skin. The worm at this stage is an elongated muscular sac filled with minute active embryos, which number approximately three millions. The embryos are contained in a thin tubular uterus, which is suspended or floats in a liquid within the muscular body-wall of the worm. This liquid appears to have a toxic effect when it is liberated into the tissues of the host by the rupture of the muscular wall of the worm in the neighbourhood of its head. The escape of this fluid into the tissues of the host causes certain early symptoms of the disease (see p. 66) and the formation of a blister over the site of the head of the worm. The uterus of the worm prolapses through the rupture in the body-wall of the worm, and its open anterior end thus comes to lie in the blister fluid. These phenomena together constitute the first stage in the parturition of the worm.

2.—LIFE HISTORY OF THE WORM

*Discharge of
embryos from
uterus*

The embryos have to pass their next stage of development in water. Some observers credit the worm with the instinct to seek those cutaneous surfaces which most frequently come in contact with water and assert also that the worm can be stimulated to discharge its young into water when this element is brought in contact with its body. Neither of these statements is correct. Blisters develop more often in the lower extremities than in the upper, although the latter are more frequently in contact with water. It can be shown also that the application of cold, not necessarily of water, to the surface of the affected area, as for example by means of an ethyl-chloride spray, causes the expulsion of embryos from the uterus. When cold is applied to the surface of the skin in the neighbourhood of the worm, the prolapsed portion of the uterus almost immediately fills with a cream-like fluid. If some of this fluid is allowed

to fall into water it becomes dispersed, and, if the water is now viewed against the light in a test-tube, myriads of minute wriggling worms may be seen. They are just visible to the naked eye and can be easily demonstrated by a hand lens. The embryo is about one-fiftieth of an inch in length and one-fifteen-hundredth of an inch in breadth at the widest part. The body terminates in a very long, sharp-pointed, bristle-like tail, the function of which will be referred to presently (see Fig. 6).

Fedchenko showed as long ago as 1870 that the young guinea-worms will die in water in three or four days. They will not grow or develop further unless they can enter the body of a minute crustacean called cyclops. These cyclops abound in the water of wells and tanks in many parts of the tropics as well as in other parts of the world. A cyclops measures about one-twentieth of an inch in length and about one-eightieth of an inch in breadth. It is a lozenge-shaped, semi-transparent, shrimp-like animal easily seen, when looked for, by the naked eye as it swims in water with a jerky movement.



FIG. 6—Guinea-worm embryos: note long sharp-pointed tail. $\times 100$

*Inter-
mediate
host*

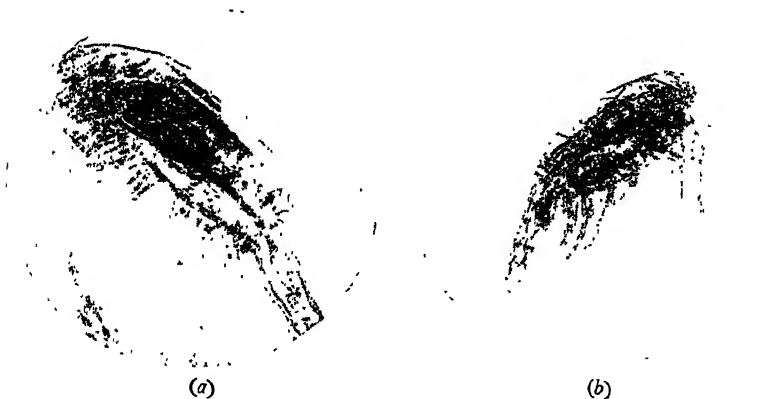


FIG. 7.—(a) Female cyclops with coiled guinea-worm embryos in stomach two hours after feeding on them; (b) cyclops with guinea-worm embryos in haemocoel some days after feeding on them. $\times 70$

Leiper (1906) was the first to show that cyclops feed upon guinea-worm embryos and that the worm enters the body of a cyclops through its mouth and not by piercing the hard integument with its sharp tail, as Fedchenko supposed. When a cyclops is examined under a micro-

*Entrance of
embryos into
cyclops*

scope with a low-power objective, the stomach may be seen suspended between the mouth and rectum. A space, the haemocoel, surrounds the stomach and lies between it and the transparent, relatively hard integument or carapace; when the cyclops is alive the stomach moves rhythmically within this space. If guinea-worm embryos have been swallowed quite recently, i.e. within two hours, they can be seen coiled up like a watch-spring within the stomach of the cyclops (see Fig. 7). While still held firmly by the tonic contraction of the stomach, from time to time an embryo suddenly uncoils; it is then that the sharp-pointed tail (used as a fulcrum to effect this movement) exerts pressure

on the delicate wall of the stomach, which is easily perforated; the embryo then slips through the opening thus made into the haemocoel (see Fig. 7, *b*).

When a guinea-worm embryo has passed into the haemocoel of a cyclops it can live for weeks, indeed for so long as its host remains alive. During this period the embryo sheds its skin once or twice, losing in this process the sharp-pointed tail. The young guinea-worm then assumes the form shown in Fig. 8.

The time occupied in these moults depends to some extent on the temperature of the water in which the cyclops live. At a temperature of about 80° F. the moults are in my experience completed in from eight to twelve days and a resting period follows. According to Leiper, however, the period required to complete the development of the young guinea-worm in a cyclops may

be as long as five weeks in the most favourable circumstances. Before further development can occur, a change of environment is again necessary. This change is effected when a man drinks water containing infected cyclops.

Leiper (1906) showed that hydrochloric acid in the concentration present in human gastric juice speedily kills a cyclops but stimulates the young guinea-worms within the cyclops to make active efforts to escape from the carapace. He advanced this observation as an argument in favour of the view that man acquires guinea-worm disease by drinking water containing infected cyclops.

Meanwhile epidemiological evidence collected by a number of workers had already made this conclusion more than probable. Powell, for example, reported that on April 20th 1902 sixteen gentlemen, inhabitants of Bombay, went with five servants for an excursion to the village of Malad some miles distant from the city. Many people in this village suffered from guinea-worm disease. The party remained in

*Develop-
ment of
larva in
cyclops*

*Time
required to
mature in
the cyclops*

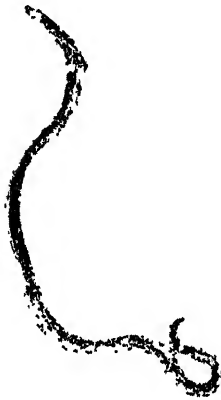


FIG. 8.—Mature guinea-worm larva, possibly female, dissected from cyclops three weeks after entering haemocoel. Stained with Leishman's stain. $\times 60$

*Transfer of
parasite from
cyclops to
man*

the village for two days only, but during their visit drank unfiltered water from the village well; they then returned to Bombay, a city with a good water-supply and free from the disease. On April 2nd 1903, one of the party developed guinea-worm disease, another was attacked on May 1st, and five others between that date and May 20th. Seven of the twenty-one persons in this party were affected. The shortest incubation period was 345 days.

3.—EXPERIMENTAL INFECTIONS

In 1907 Leiper succeeded in infecting a monkey which had been fed on infected cyclops. Three immature, unfertilized female guinea-worms measuring 30 centimetres in length, and two small males 22 millimetres long, were found in this monkey when it died six months after it had been fed on the cyclops.

*Experimental
infection of
a monkey*

Moorthy and Sweet (1936) infected dogs by allowing them to swallow cyclops which had been infected some weeks previously with guinea-worm embryos derived from men. They experimented in all upon twenty-eight puppies, but only one of these animals survived long enough to permit the full development of the parasites. This animal on April 20th 1936, 350 days after the first feed on infected cyclops, became restless, refused food, and had a rectal temperature of 104° F.; it continually licked its left hind foot, and here a small blister was noted. When the blister was opened, the head of the worm was revealed, and guinea-worm embryos were collected in the usual way. On subsequent dates four other worms were found in various parts of the body.

*Experimental
infection of
dogs*

The majority of the other puppies experimented upon died of inter-current disease. Post-mortem examinations, however, were made on these animals, but nothing of interest to the experiment was found till the last four necropsies. In the connective tissues of these four dogs two types of nematode were found. One hundred and thirty-seven specimens of a longer type measuring from seven to forty-nine centimetres in length were found, which Moorthy and Sweet recognized as female guinea-worms in various stages of development. There were also thirty-six shorter worms, almost two and a half centimetres in length, which they believed were more or less mature male guinea-worms. Their description of both types of worms, though somewhat meagre, leaves little doubt that they were guinea-worms. Dr. Moorthy is at present engaged on a more complete study of the material he has collected.

*Post-mortem
examina-
tions of
experimental
dogs*

It is interesting to note that worms were found in the retro-oesophageal connective tissue in all the four puppies in which worms were discovered. In one case worms were detected in the meninges and in another in the orbit; more frequently they were found in the thoracic and abdominal wall and in the extremities. It is also noteworthy that these

*Sites of
parasites in
experimental
dogs*

workers believe that, in view of the fact that it was only in the last four necropsies which they made that the worms were found, they may have missed them in the earlier necropsies 'on account of lack of knowledge as to just where and how to search'. Possibly other workers who have failed to find the worms in animals experimentally fed with infected cyclops may have overlooked the worms for similar reasons.

*Experimental
infection of
men*

Liston, Turkhud, and Bhawe, having failed to infect twenty-five monkeys (*Macacus sinicus*) by feeding them on infected cyclops, resorted to an experiment on men. On April 5th 1912, five volunteers each drank five infected cyclops in water. The cyclops each contained one or more embryos which had been fed to the cyclops on March 24th, so that the young guinea-worms had passed only twelve days in the cyclops. On March 18th 1913, 348 days after drinking the

infected cyclops, one of the volunteers developed a very small blister on the dorsum of his right foot. The development of the blister was associated with the usual early symptoms of the disease. By March 30th the blister had assumed the appearance shown in Fig. 9. The blister was then opened, and a large number of embryos were collected daily until April 14th, when the worm broke. Some



FIG. 9.—Blister stage in experimental infection with guinea-worm disease

local swelling and suppuration supervened but eventually subsided. The other four volunteers did not show any signs or symptoms of the disease. One of the volunteers, however, when his blood was examined in October 1913, showed an eosinophilia of 34 per cent. Almost twenty years later, while examining his flank on account of a dull aching pain which frequently developed in his side after a long railway or motor car journey, he found a hard, calcified, pencil-like nodule beneath the skin. Early in 1936—almost twenty-four years after swallowing the infected cyclops—an X-ray photograph showed appearances which suggested that a guinea-worm had become calcified in the subcutaneous tissues of his right flank.

4.—CLINICAL PICTURE

(1)—Early Symptoms

(a) Onset

The onset of the disease is often sudden.

*Illustrative
case*

A man, aged about forty years, was feeling perfectly well when he awakened in the morning. In accordance with his usual practice he left his house, bare-footed, to attend to the calls of nature and was returning home about eight o'clock in the morning, when he suddenly became ill. He felt giddy and faint, his foot swelled rapidly, becoming hot and painful,

and a shotty lump developed between his toes near the sole. An Indian doctor was summoned, who suggested that the patient had been bitten by a poisonous snake; the patient, however, had neither heard nor seen a reptile. Some three hours after the onset of the illness I was called in consultation to see the patient, who was then in bed feeling very ill. His face was swollen, particularly below the eyes and around the lips and ears. These parts were also slightly cyanosed. His pulse was slow and irregular and his heart-sounds were feeble. During this medical examination the patient fainted, but he soon recovered. A cold clammy sweat broke out on his forehead; he felt thirsty and later vomited but gradually became more comfortable. Meanwhile he complained of intense itching of the skin, and urticarial wheals appeared in various parts of his body.

Intense urticaria, fleeting oedemas, a fluttering pulse, giddiness, pallor, sickness, thirst, and collapse presage the onset of guinea-worm disease. Fairley (1924) discussed these early symptoms in detail and, in addition to the case described above, which he saw with me, mentioned another patient with asthmatic symptoms which were immediately relieved by an injection of adrenaline. *Allergic symptoms at onset*

Fairley suggested that 'perhaps the symptom complex is allergic in nature', but 'on the other hand that the clinical features may be equally explained by the direct action of helminthic toxins on the autonomous nervous system'. I have seen two cases, one a boy stung by a wasp, the other a young man stung by a number of honey-bees, in whom very similar symptoms—urticaria, oedema, fluttering pulse, nausea, pallor, and thirst—came on a few minutes after the stings had been inflicted, and depended, without doubt, on the rate at which the poison had been absorbed. In guinea-worm disease the toxin is suddenly discharged into the tissues in the neighbourhood of the head of the worm when the body ruptures, there to liberate the gravid uterus containing the embryos. *Cause of symptoms*

(b) *The Guinea-Worm Blister*

The liberation of this toxin in the neighbourhood of the head of the worm results in the development of a blister over the head of the worm. The toxic symptoms soon pass off, and may even not be noticed in every case of the disease, but a blister forms immediately above the head of the worm in almost all cases. Some persons who have been infected, however, are quite free from symptoms of any kind. In these cases the worm dies prematurely, i.e. before parturition, and either becomes calcified or is absorbed in the tissues.

The pathological details of blister formation are described and well illustrated in a paper by Fairley and Liston (1924). The blister when first visible is small, but gradually enlarges, forming a dome-shaped projection. In a few days it may be from one to two inches in diameter (see Fig. 9). The removal of the superficial horny layer of the skin covering the blister reveals a yellowish gelatinous base consisting of fibrin infiltrated with inflammatory cells and containing a number of guinea-worm embryos. When this gelatinous layer has been removed, *Development of blister*

a glistening, red, granulating, almost circular surface is revealed. In the centre of this surface a small ivory-white object is generally visible, the head of the worm, and protruding from one side near the head a white, diaphanous, membranous, collapsed tube about one-thirtieth of an inch in diameter may be seen. This is the prolapsed uterus of the worm.

(c) *Detection of Worm*

Palpation

Palpation in the neighbourhood of the blister may reveal the presence of the long, thread-like guinea-worm lying in the subcutaneous tissue beneath the skin and extending from the blister in a tortuous fashion a foot or more away from it. Sometimes the worm is detected by palpation before the blister is formed, for cases occur in groups of men, and the presence of a worm or worms may be suspected and discovered in the absence of any symptoms. Patients have told me that they have noticed the worm moving in the tissues, but in such cases as I have been able to observe the worm occupied the same position for a period of a week or more before it reached maturity. There is certainly no active traversing of the tissues such as is well known to occur in the case of certain other filariae, for example *Loa loa* and *Acanthocheilonema perstans*.

While living in the tissues the worm causes little or no reaction till it reaches maturity, when the blister forms. In rare instances there are deep-seated abscesses containing a blood-stained, purulent fluid associated with the macerated remains of a guinea-worm.

(d) *Sites of Blisters and Number of Parasites*

Guinea-worm blisters may occur in any part of the body, but are far more frequent on the lower extremities than elsewhere; Fairley (1924) recorded 218 blisters on the legs in an examination of the site selected by 252 worms. Of these 218 blisters, as many as 108 developed on the feet, 92 on the leg, and 18 on the thigh. An upper extremity was the site chosen in 14 cases and the trunk in 11. Rarer sites for the blister are the scrotum, the penis, the vulva, and the tongue and mouth. The skin of the scalp, neck, or face is seldom the site of a blister.

Number of worms present

More than one guinea-worm may be present in a patient at the same time. In the town of Ranebannur in the Deccan, India, in March 1915, among 202 cases seen there, 127 had one worm only, 44 had two, 11 had three, 7 had four, 4 had five, 4 had nine worms, and six, seven, eight, ten, and twenty-four worms were detected at one time in individual cases.

(e) *Infection of Water-Supply by Patient*

The sufferer repairs to the village tank or well to draw water for domestic purposes or to use it to cool his hot and swollen limb. Here he bathes the affected part, probably opening the blister at the same time. The cold water stimulates the uterus to contract, and embryos thus find their way into the village water-supply. The patient now returns to his home, plucking a few leaves from some tree on the way to cover

the blistered surface. These are bound to the limb with a piece of cloth, while a charm, a peacock's feather, or some cowries threaded on a string and wound round the ankle, completes the dressing. Visits may be paid daily to the village water-supply, where the wound may be washed and re-dressed, the water-supply being perchance reinfected with guinea-worm embryos.

(2)—Later Symptoms and Complications

Meanwhile the worm begins to protrude from the wound, and the patient is tempted to hasten its departure from his body by pulling it out gently (see Fig. 10). He knows that if the worm breaks trouble is in store for him, for the charm was applied to avert this disaster. On the surface of the wound, pyogenic organisms flourish. The worm is elastic and, when dragged upon and released, retracts into the channel it has made for itself, thus drawing into the tissues the organisms upon its soiled surface. Little harm follows so long as the worm remains intact and acts as an efficient drain, but, when the worm breaks and retracts some distance up its canal, free drainage is checked by closure of the mouth of the sinus. The toxins produced by the bacteria are retained within the sinus, and the conditions are established for acute inflammation and suppuration, the extent and severity of which depend on the course of the worm in the tissues as well as on the nature and virulence of the organisms. When this accident occurs fever almost always follows; the lymphatic glands draining the area become painful and enlarged, the tissues in the immediate neighbourhood of the ruptured worm become intensely inflamed, and an abscess forms (see Fig. 11). The fever continues till the pus is evacuated either by ulceration through the skin or by incision. The abscess or abscesses may be quite small, or may be very large and contain a pint or more of pus.

Infection of sinus



FIG. 10.—Guinea-worm partly extracted; note turgid and twisted cephalic extremity with delicate uterine tube hanging from point posterior to, but near, the mouth



FIG. 11.—Stage of abscess formation after guinea-worm has broken in the course of extraction

Gangrene may set in, and, in rare cases, amputation of the limb may be necessary to save the life of the patient. This stage of the illness may last for weeks or even months.

*Involvement
of joints*

Joints in the neighbourhood of the inflammatory process may become involved, and ankylosis of joints and contractures of the muscles may cause permanent injury. The ankle-joint and the knee-joint are most frequently affected. In villages heavily infected by the disease there may be patients compelled to walk on their toes because of ankylosis of the ankle-joint in the extended position.

5.—TREATMENT

Fortunate is the patient who succeeds in extracting the worm complete without breaking it. This may be accomplished in the course of a week or two. The usual practice is to pull out a small portion of the worm daily and roll this bit round a stick or piece of cloth, retaining it under the dressing till the worm is removed.

(1)—Treatment by 'Tumri Wallas'

*Extraction
of whole
worm*

In many parts of India, where the disease is common, there is a type of barber surgeons called 'tumri wallas' after the instrument they use in extracting the worm. They are sometimes known as 'naru wallas' ('guinea-worm men') because they are skilled in removing guinea-worms through incisions made in the skin either before or after the blister has formed. Their method of procedure is to locate the course of the worm by careful palpation; then, placing the affected limb or part in a suitable position, with the muscles relaxed, they pick up a piece of skin directly over the worm by inserting a needle through it. A small pyramid or papilla of skin is raised directly over the worm by lifting the needle away from the surface, and an incision is made through and around the base of the papilla with a sharp knife or razor, so that a button-hole opening in the skin is formed, and a small portion of skin is removed transfixed to the needle. After the bleeding has been staunched by pressure, a thin layer of tissue, immediately below the skin and directly over the worm, is picked up with the needle through the first incision. This is removed in a similar way to that adopted for the skin incision. Layer after layer is cut out till the worm is clearly exposed, completely free from overlying tissue. It is then lifted out of the channel in which it rests, with the aid of the needle passed under it. Traction is now exerted upon either end alternately and this is assisted by massage, till a large loop or the whole worm is withdrawn.

*Extraction
of retained
parts of
worm*

If the whole worm cannot be removed, that part which has been extracted is broken off, leaving the head or tail, or both, in the tissues. The next procedure is to sprinkle a little oil or water upon the surface of the skin around the wound. Then a hollow metal cone open at both ends, called a 'tumri', is applied over the wound. This instrument

measures in length from five to six inches; the diameter of the basal opening is about one and a half inches and of the apical opening half an inch. The operator now applies his mouth to the apical opening, keeping the basal opening firmly applied over the wound. He sucks the air out of the cone, producing a marked negative pressure within the cylinder. When the operator has nearly exhausted himself with this sucking operation, he applies his tongue to the upper opening; a moistened finger, generally the thumb, is then rapidly substituted as the tongue is withdrawn. In this way a negative pressure within the tumri is maintained for some minutes. A mantra or incantation may be delivered during this period of waiting. Often a second suction with the mouth is repeated, and massage may be applied to the skin around the wound, while a negative pressure is maintained within the tumri. In a few minutes more the finger is removed from the apex of the tumri, air enters, and the instrument is removed. A mass of blood clot now lies on the wound, in which the parts of the worm which had not been removed during the first part of the operation will be found. No deception is practised by these 'tumri wallas', though this was maintained by Mirza (1929). They are exceedingly skilled in this operation, but are devoid of any modern knowledge of aseptic surgery, so that suppuration sometimes follows their operations.

(2)—Modern Treatment

The modern treatment of guinea-worm disease closely follows the principles of the Indian treatment outlined above. The method of choice in treating guinea-worm disease is the extraction of the worm by an incision through the skin (see Fig. 12), much after the manner of the tumri walla but improving upon his technique by using an anaesthetic injection to relieve pain, by adopting aseptic precautions to prevent suppuration, and by using mechanical instead of oral suction.

This operation, however, may not always be practicable, either because the course of the worm in the tissues cannot be detected by palpation, or because the patient objects to any surgical procedure. In such cases the blister is opened and the worm encouraged to discharge its young by the application of cold to the skin in the neighbourhood of the blister where the body of the worm lies; this can be effected by the use of the ethyl chloride spray, or ice, or an evaporating lotion. A dressing of lint soaked in Wright's hypertonic saline and citrate solution (sodium chloride 5 per cent, sodium citrate 0.5 per cent in water) is then applied.

*Similarity
to treatment
by natives*



*Application
of cold
to skin*

FIG. 12.—Patient with 24 guinea-worms; loop of one worm extracted through small incision in skin

The wet lint is completely covered with gutta-percha tissue or oiled silk, and a bandage is applied. The worm should be carefully extracted daily; the portion withdrawn is wrapped round a piece of lint and retained beneath the dressing till the whole worm has been removed. The posterior extremity of the worm can be readily recognized by its hooked termination. Abscesses, if they form, should be opened with the usual aseptic precautions.

The injection of the worm with poisonous substances with the object of killing it, or the use of intravenous injections, such as tartar emetic or arsphenamine, to cure the disease, are not recommended.

6.—PREVENTION OF GUINEA-WORM DISEASE

Possible preventive measures

The prevention of guinea-worm disease is based on the life history of the worm, and preventive measures therefore consist of (a) the application of measures to secure the protection of drinking-water supplies from ingress of guinea-worm embryos, and (b) the removal or destruction of cyclops in drinking water.

Problem in small village

The problem is, however, not quite so simple as it at first sight appears, because of certain social and economic difficulties which have to be overcome in the first instance. For example, in a small village with one shallow well yielding a meagre supply of water in the dry season, it was found that on an average 40 persons in a total population of 159 were attacked each year, in some cases repeatedly. Careful estimates of the costs of deepening the well to secure a more abundant supply of water, and of enclosing it and supplying pumps, cisterns, and taps to prevent contamination, worked out at about one-third less than the estimated loss incurred as a result of guinea-worm infection. The annual cost of the scheme was three times that of supplying water under the old conditions—a serious expenditure to persons in the economic status of the villagers. In small towns prophylaxis on these lines is still more difficult and costly. In one town, with a population of just under 14,000, 11 step wells accounted for 115 cases, one tank for 64, and another for 21. None of those who suffered from the disease obtained their drinking water from draw-wells. Proposals for obtaining a better water-supply could not be carried out for want of funds, and even for the enclosure of existing water-supplies it was difficult to secure the co-operation of the inhabitants. In any similar circumstances it is possible to apply the alternative method of prevention mentioned below, namely, to remove infected cyclops from all drinking-water or to destroy the cyclops in the wells by means of chemical agents.

In small town

(1)—Removal of Cyclops by Filtration

It is certainly true that no other water-borne disease can be prevented so easily as guinea-worm disease, for cyclops, the intermediary hosts of the parasites, are of such a size that they can be removed from the

water, thus rendering it safe, by so simple an expedient as filtering it through a piece of cloth. The incubation period of the disease, however, is so long, almost a year, that the first enthusiasm in adopting so simple a measure of ensuring safety is liable to wane before it can become effective. It is, however, a means of securing freedom from the disease which any individual with understanding can adopt with ease and certainty.

(2)—Destruction of Cyclops by Potassium Permanganate

Cyclops can be killed in water by potassium permanganate in so small a concentration as to produce only a light pink tinge in the water. A concentration of 0.01 gram per litre will generally suffice to kill cyclops in a few hours. Such a concentration imparts very little taste to the water, and such taste as may be present immediately the salt is added passes away if the water is allowed to stand for a short period. Water treated in this way is quite safe to drink. But potassium permanganate in the concentration mentioned does not appear to injure the eggs of cyclops, so that the crustaceans reappear after a period. A well therefore which has been made safe by treatment with potassium permanganate may become restocked with cyclops and may be reinfected in the course of a few weeks if guinea-worm embryos are reintroduced. The following experience in the village of Sarsola illustrates these points. A census of the village showed that 39 per cent of the villagers had suffered from the disease at some time or another during their lives, and in the year in which this experiment is recorded 10.78 per cent of the villagers were affected. The water-supply of the village was derived from two draw-wells. The protecting wall of one of these wells was dilapidated, and an examination of the water in this well showed not only that numerous cyclops were present in it but that 38.6 per cent of them were infected with guinea-worm larvae. The well was treated on March 16th in the usual way with three pounds of potassium permanganate, until a pale pink colour was imparted to the water. On March 23rd examination of the water of the well failed to reveal any living cyclops. On the 30th of the month a large number of daphnia and a few cyclops were found in the water. By April 8th the number of cyclops had increased and now 5.9 per cent of them contained guinea-worm larvae. An examination on April 20th showed a still further increase in the number of cyclops and 14 per cent of these were by this date infected with guinea-worms.

*Necessary
concentration
of
permanganate*

*Return
of infection
after
permanganate
treatment*

*Sociological
aspect of
problem*

The prevention of guinea-worm disease is not essentially a medical problem; the difficulties which have to be overcome in eradicating it have mainly a sociological and economic basis and resolve themselves into combating the ignorance, the habits, and prejudices as well as the lack of co-operation among the primitive people who suffer from this disease.

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GUMS

See DENTAL SEPSIS IN RELATION TO SYSTEMIC DISEASE,
Vol. III, p. 596; DENTITION, Vol. III, p. 603; and
MOUTH DISEASES

HAEMATEMESIS

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Reference may also be made to the following titles:

ANAEMIA	LIVER DISEASES
GASTRITIS	PEPTIC ULCER
STOMACH DISEASES	

1.—DEFINITION

582.] The word haematemesis is generally applied to the vomiting of obvious blood in considerable amount; it does not refer to 'occult blood' and is seldom applied to 'coffee grounds'. The event is alarming and therefore emphasized and recorded; the amount lost may be much exaggerated and is rarely measured; the loss of a pint is a large haemorrhage. The blood may come from arteries, veins, or capillaries, with variations in symptoms; haematemesis is often accompanied by melaena, especially in bleeding from the duodenum. *Sources of blood*

2.—AETIOLOGY

Haematemesis, as it occurs in the Dunedin Hospital of about 300 beds, was reviewed by Russell Chisholm (1934) who found ten instances among 756 adult medical admissions in one year, and 100 cases in ten years. I

have drawn independently on the records of the Dunedin Hospital for the purpose of this article. A survey of recent publications on haematemeses at once shows remarkable discrepancies in its incidence, causes, and especially mortality. To take an extreme instance, the mortality in a series from St. Thomas's Hospital was ten times as high as one collected chiefly at Guy's Hospital.

Haematemeses is not very common, for in the absence of an actual breach of surface the stomach does not readily bleed. In chronic azotaemic nephritis, for instance, although vomiting may be frequent, haematemeses is quite rare; and in purpura and other haemorrhagic states in which there is bleeding from many mucous surfaces copious gastric haemorrhage is seldom seen.

Causes

The causes of haematemeses may be classified as follows:

Ulceration of stomach and duodenum

(i) Gastric and duodenal ulceration, acute and chronic. Peptic ulcers may also occur at the lower end of the oesophagus or in the jejunum after gastro-enterostomy.

Haematemeses due to peptic ulcer of the stomach, of the first part of the duodenum, of the jejunum, and in rare instances of the lower end of the oesophagus, is accompanied by melaena. Duodenal is much commoner than gastric ulcer, and therefore, although it may cause melaena alone, it is probably more often than gastric ulcer responsible for haematemeses.

Superficial erosions of mucosa

(ii) Superficial erosions of the gastric mucosa (exulceratio simplex, Dieulafoy) with pore-like erosions of the gastric arteries (L. Steven), due to bacterial or toxic factors, for example in pneumonia or in oral sepsis, may cause severe haematemeses.

Acute ulcer may also be due to toxæmia affecting the mucous membrane. The haematemeses which occurs in severe haemorrhagic forms of smallpox and scarlet fever is assumed to arise from this cause. Similarly any focal sepsis may cause bleeding, and oral sepsis is held greatly to aggravate peptic ulcer. It is assumed that acute gastritis is thus set up, which may go on to erosion of the mucous membrane and ulceration. Infection within the abdomen is particularly important, and, in many cases of haematemeses which have not shown any ulcer at operation, cholecystitis or appendicitis has been present, the haemorrhage being presumably due to toxic gastritis and ceasing after removal of the inflamed viscus. Edwards recognized three degrees of gastritis with the gastroscope, and described haemorrhage in the catarrhal stage. In this connexion may be noted the incidence of haemorrhage in alcoholic gastritis; among 100 admissions for alcoholism at Dunedin there were six cases of haematemeses. In Chisholm's series seventeen cases of haematemeses appeared to be due to acute peptic ulcer, with one death in which an acute ulcer was found with an eroded vein.

Alcoholic gastritis

Gastrostaxis

A condition in anaemic girls imitating gastric ulcer was described as 'gastrostaxis' by Hale White (1901); it was probably due to small erosions which caused symptoms obviously out of proportion to the lesion; but, like chlorosis, it has now become very rare.

(iii) Ulceration of varicose veins at the lower end of the oesophagus and far less often in the stomach. This occurs in chronic obstruction of the portal vein, and is most often due to multilobular cirrhosis of the liver; but it also occurs in chronic splenic anaemia and in adhesive pylephlebitis (in one series in 44 per cent of cases). One condition included under the heading of chronic splenic anaemia is due to portal thrombosis and may be manifested by severe recurrent attacks of haematemesis.

*Ulceration of
oesophageal
varix*

Bulmer found that in twenty-five years at the Birmingham General Hospital twenty-five cases of hepatic cirrhosis were admitted for haematemesis; there were eight deaths in this series. Hellier found ten cases of cirrhosis among 303 admissions for haematemesis to the Leeds General Infirmary, all in men between the ages of thirty-six and seventy-two; two died and in one of these there was found to be an acute ulcer.

Incidence

(iv) Carcinoma of the stomach. In this condition the vomited material usually contains red blood corpuscles—'coffee grounds'—but in rather rare instances copious haematemesis occurs. It may be an early symptom when the carcinoma is latent or may occur shortly before death, which may thus be accelerated (Osler and McCrae).

*Gastric
carcinoma*

Chisholm found three cases of gastric carcinoma among a hundred of haematemesis; in a series of cases of gastric carcinoma which I analysed haematemesis was present in 11 per cent; it was present in 8 per cent of a series recorded by Hurst and Stewart.

Incidence

(v) A number of other conditions may be associated with and play a part in the causation of haematemesis. Toxic and infective states which cause haemorrhages generally may be responsible for haemorrhage into the stomach, and haematemesis may be a sign of the severity of the infection, as in the malignant forms of the exanthemata.

*Toxic and
infective
states*

High blood-pressure may cause bleeding from any mucous surface, and its presence adds to the risk of haemorrhage from peptic ulcer, both on account of the raised pressure and of the accompanying arteriosclerosis, an important factor in ulcer bleeding. Haematemesis is rarely mentioned in the literature of hyperpiesia. Clifford Allbutt and Fishberg both noted it as 'rare'.

*High blood-
pressure*

In a group of cases under my observation, classed as 'undiagnosed', were the following: (i) A woman, aged fifty, not suffering from dyspepsia, suddenly vomited two pints of blood. The blood-pressure was 200 systolic, 110 diastolic; the haemoglobin was 55 per cent; the radiograph was negative. The patient recovered. (ii) A woman, aged seventy, with slight dyspepsia, had a severe haematemesis. The blood-pressure was 216 systolic, 180 diastolic. This patient recovered also. I found three similar cases among 145 New Zealand war-pensioners' records, and have treated several others on the assumption that ulcer was not present, with satisfactory results.

In some forms of disease of the blood-forming organs, e.g. acute leukaemia, bleeding may occur into the stomach, but is rather an index of the gravity of the disease than in itself dangerous. I have seen it in

*Diseases of
blood-forming
organs*

*Hepatic
diseases
Chronic
nephritis
Vicarious
menstruation
Melaena
neonatorum
Gumma of
stomach
Unexplained
cases*

erythraemia and purpura. Haematemesis may occur in acute necrosis of the liver, and in cholaemia especially of obstructive jaundice. It is rare in congestive heart failure, but I have observed it in three cases previously regarded as peptic ulcer. Vicarious menstruation is not now regarded as an explanation of haematemesis which happens to occur when a menstrual period is due. Profuse haematemesis may occur in melaena neonatorum (see p. 153). In exceptional cases a gumma of the stomach may ulcerate and cause haematemesis.

(vi) Unexplained cases are found in all series. Among six years' admissions to the Hospital I found ten cases, varying from the age of two to eighty-six, in which copious haematemesis occurred, but no adequate cause for the bleeding was found; all the patients recovered.

3.—CLINICAL PICTURE

Onset

The occurrence of haematemesis is often immediately preceded by abdominal discomfort and a feeling of faintness, and is followed by anxiety, restlessness, and symptoms of collapse. Urgent thirst is likely to follow a large haematemesis. The pulse, arterial blood-pressure, and the general state of the patient must be watched for evidence of continued or recurrent haemorrhage.

The onset may have been preceded by dyspepsia of some duration pointing to hyperchlorhydria or to peptic ulcer. Sudden haematemesis with few if any previous signs of illness is often due to latent hepatic cirrhosis, the compensatory varicose veins at the lower end of the oesophagus having undergone ulceration. In some cases of cirrhosis, however, haematemesis occurs late when ascites has appeared.

4.—PROGNOSIS

*Factors
determining
prognosis*

The underlying cause, such as peptic ulcer, hepatic cirrhosis, or gastric carcinoma, largely determines the ultimate outlook. The immediate prognosis of haematemesis must depend on the amount of blood lost, in other words on the degree of anaemia thus caused, and on the patient's general condition and power of recovery.

According to Conybeare 20 per cent of peptic ulcers give rise to haematemesis. Although peptic ulcer is more common and haematemesis more often fatal in men, women are more often the subjects of haematemesis. The state of the blood-vessels exposed in peptic ulcers, i.e. whether healthy or arteriosclerotic, would probably bear on the liability to bleeding from the ulcer, and therefore advancing age with the accompanying liability to arteriosclerosis may render the outlook more serious.

*Mortality
in chronic
peptic ulcer*

The mortality from haematemesis in chronic peptic ulcer has been variously estimated. In Hurst's 500 cases it was 2.5 per cent, but in

Bulmer's 500 cases of haematemesis from various causes, the total mortality of which was 13 per cent, the rate in ulcer cases was 10·7 per cent. Among more than 250 cases at the London Hospital during five years the percentage of deaths was 11 (Aitken). At Leeds the death rate in 200 cases was 13 per cent (Hellier); and at St. Thomas's Hospital, London, Chiesman found that in nearly 200 cases it was 25 per cent, and that in cases of recurrent haematemesis it was 74 per cent. Most observers agree that a single large haemorrhage is rarely fatal, the great risk being from recurrence. Thus Aitken separated 'grave' and 'less severe' cases; grave cases are those with recurrent haemorrhage in which the red corpuscles are reduced below 2 millions per cubic millimetre and the haemoglobin is below 40 per cent. For these he advised medical treatment together with blood transfusion and, if haemorrhage continued, surgical treatment. Davies and Nevin, following Aitken's classification, found in nearly 400 cases at St. Thomas's Hospital a total mortality of 21·5 per cent; in less severe cases it was 6·3 per cent, in grave cases 45·1 per cent, and in cases with continuous bleeding 52·8 per cent.

'Grave' cases

In hepatic cirrhosis haematemesis is seldom fatal; in 96 fatal cases haematemesis was the sole cause in seven; when it does cause death it is said to be generally in the first attack (Preble).

Mortality in hepatic cirrhosis

In the rather indefinite group of cases formerly included under the heading of splenic anaemia, especially when complicated by the development of hepatic cirrhosis (Banti's disease), the tendency to recurrent haematemesis renders the outlook grave unless splenectomy is performed. Hutchison mentioned the case of a woman who was admitted to the London Hospital for severe haematemesis on thirteen occasions in fifteen years. Among fourteen patients, most of them under 30 years of age, five died (Hellier). As splenectomy has been followed by fatal haematemesis, probably from portal thrombosis, it is important, before the operation is undertaken, that a platelet count should be made; if this is raised above the normal (250,000 per c.mm.) the operation should not be performed.

Chronic splenic anaemia

The occurrence of haematemesis in a case of head injury would suggest that the base of the skull has been fractured and blood from that source swallowed. Black vomit in yellow fever makes the prognosis extremely grave.

Other associated conditions

5.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

Vomited material darkened by some articles of food, such as blackberries, has been known to imitate blood, but microscopical examination should in a doubtful case settle the question. The diagnosis from haemoptysis should be settled by the points given on page 135, especially by the acid reaction and the presence of food in blood vomited up in contrast to the bright and frothy character and alkaline reaction of the blood coughed up in haemoptysis.

Diagnosis from haemoptysis

Swallowed blood

Blood from posterior epistaxis, from hereditary telangiectases in the nasopharynx, from a fracture of the base of the skull, from soft adenoids especially after an operation for their removal, and from tonsillectomy, may be swallowed and, if vomiting occurs, may suggest bleeding from the stomach; but the above circumstances and evidence of a bleeding spot or of blood trickling down from the posterior nares should prevent any mistake in diagnosis.

Significance of history and physical signs

Diagnosis of the cause of haematemesis in a given case depends on the history and the physical signs. Thus a record of the symptoms of hyperchlorhydria, hunger pains and so forth, would point to peptic ulcer; a history of alcoholic dyspepsia, a large liver, and some degree of splenomegaly would suggest hepatic cirrhosis; considerable splenomegaly would indicate splenic anaemia and Banti's disease; and a tumour in the region of the stomach, carcinoma.

Acute ulcer

Acute peptic ulcer is often diagnosed in profuse haematemesis without previous dyspepsia; sometimes an ulcer is found and sometimes not; an acute ulcer may be invisible on X-ray examination, or may have healed during treatment before the examination can be made.

6.—TREATMENT

Immediate treatment

The immediate treatment of haematemesis is complete rest, mental as well as physical. An injection of morphine sulphate $\frac{1}{4}$ to $\frac{3}{8}$ grain is far preferable to any drug, such as luminal, by the mouth. With the morphine may be combined $\frac{1}{100}$ to $\frac{1}{60}$ grain of atropine sulphate. The injection may be repeated as required, but with due care, for Bulmer raised the question whether excess of morphine may not account for the present mortality.

Ulceration of varix

In haematemesis due to ulceration of an oesophageal varix in hepatic cirrhosis 5 minims of solution of adrenaline hydrochloride 1 in 1,000 may be taken in water in order to exert a local action on the varix. Surgically, ligature of the coronary vein of the stomach has been advocated (Walters and McIndoe).

Use of enema

The bowel should be washed out with a simple enema, and 10 to 15 fluid ounces of physiological saline containing 4 per cent of glucose should be given *per rectum* two or three times daily; or a rectal drip may be used. An ice bag may be kept on the epigastrium. The mouth must be kept scrupulously clean, and swabbed at least three times a day. No food should be given for thirty-six to forty-eight hours. This treatment is sufficient in mild cases. Hurst recommended alkalis from the start.

*Ice bag
Care of mouth**Alkalis**Treatment of thirst*

Thirst should be met by the rectal administration of fluid—saline and glucose—by some simple enema, or preferably by the Murphy constant drip method.

Continuous drip blood transfusion

If necessary for the exsanguineous patient, the continuous drip blood transfusion described by Marriott and Kekwick may be adopted. By

this method, which is used with much success at the Middlesex Hospital, a large amount of citrated blood, 5 litres or more, is collected in a cylinder from a series of donors and kept stirred by the passage of a stream of oxygen. The blood is slowly and continuously run into the patient's vein by gravity through a needle strapped into place.

Using Aitken's classification, the less severe cases may be treated by rest alone with or without local treatment of the stomach; the grave cases require transfusion; and if bleeding persists or recurs surgical treatment is favoured by some authorities, but the statistics are not by any means conclusive (see below). The treatment as recommended by Hurst consists in complete immobility, starvation to keep the stomach empty, administration of atropine to check gastric secretion, and neutralization of the gastric juice by the administration of 60 grains of tribasic magnesium phosphate in a little water every hour. This salt is also an aperient and helps to remove the blood in the intestine—an important part of the treatment; for it often happens that a patient becomes feverish and much worse than the blood-count would suggest, as the result, it has been thought, of the decomposition of blood in the intestine; but quite apart from gastro-intestinal haemorrhage there may be fever in cases of hepatic cirrhosis when the disease is advancing.

Treatment of less severe cases

The patient should always be nursed in a warm bed, with hot water bottles, and be reassured about his condition. The blood haemoglobin and red count should be estimated and the pulse-rate and blood-pressure taken. Variations in these figures as the case proceeds are the best indications of progress or failure. The blood should be typed in case transfusion is required.

Treatment for all cases

If bleeding continues, Hurst's method of washing out the stomach should be adopted, preferably by means of a Senoran's evacuator, but a tube and funnel may be used. The stomach tube is passed just through the cardia and the stomach is emptied. Four ounces of ice-cold water are then put in and withdrawn, and this is repeated until the water comes away uncoloured by blood, or so long as the process seems reasonable. When the stomach has been emptied for the last time, 60 minims of adrenaline hydrochloride solution 1 in 1,000 are put in and left. The cold is intended to stimulate the stomach to contract. The treatment causes remarkably little discomfort to the patient.

Treatment of persistent bleeding

If the haemoglobin falls below 40 per cent and the red corpuscles below 2 millions per cubic millimetre, transfusion is required (see Vol. II, p. 530). An amount of blood from a single half-pint to a total of a gallon in repeated injections may be needed, 500 c.c. being the usual amount for the first transfusion. There need not be any anxiety that the transfused blood will raise the blood-pressure and increase the bleeding, for it seems to exert a definitely styptic effect.

Treatment of grave cases

As recurrent or continuous bleeding is probably due to erosion of a large vessel, the prognosis becomes extremely grave. Surgical interference may then be thought necessary, but the patient's condition is obviously a serious consideration in abdominal section. Balfour stated

Treatment of recurrent or continuous bleeding

that 'the danger of succumbing to haemorrhage is less than the danger of operating during haemorrhage', but Gordon-Taylor advocated operation in uncontrolled haemorrhage and in cases in which chronic ulcer is known to be present. The question of operation must be determined by consideration of all the data in each case. Finsterer of Vienna is exceptional among surgeons in preferring to operate immediately in all cases of bleeding from a chronic ulcer, recording a mortality of 5 per cent for immediate operation and 30 per cent for late operation. In a series collected by Cullinan and Price, however, there were 18 deaths among 25 patients with haematemeses who were submitted to operation; this mortality, 72 per cent, is higher even than the 40 to 60 per cent mortality in recurrent bleeding treated medically.

After-care

In favourable cases, when bleeding has ceased, feeding by the Sippy diet (see Vol. IV, p. 47) or the less meticulous method of MacLean is begun after thirty-six to forty-eight hours. MacLean emphasized the importance of alkaline powders in large doses. Iron should be given in large doses for the anaemia, e.g. iron and ammonium citrate 30 grains or more three times daily.

Meulengracht's method

The method outlined above is the common treatment for haematemeses in England. It is attended by a mortality varying in different series from 10 to 25 per cent, which are surely unsatisfactory figures. Recently, Meulengracht (1934, 1935, 1936) adopted the method of feeding his patients from the first day after admission with a full diet, including meat, fish, vegetables, potatoes, and stewed fruit, all in purée form but as much as the patients wished, and at the same time gave alkalis to reduce the gastric acidity. This treatment is based on the view that feeding is necessary in order that the ulcers should heal, that bleeding stops when food is given, and that the presence of free acid in an otherwise empty stomach must exert an adverse influence on the healing of an ulcer. Meulengracht treated an unselected series of 273 patients, with three deaths; one aged seventy-six died within twenty-four hours, and the other two had chronic nephritis. He found that the condition of the blood improved rapidly, and convalescence was shortened.

Modification of Meulengracht's method

The method was recently used with slight modifications at St. Bartholomew's Hospital, and very satisfactory results were obtained (Witts, 1937). A diet more fluid than Meulengracht's was given which provided the patients with 2,500 to 3,500 calories a day. It included milk, cream, patent barley or strained porridge, eggs, vegetables and fruit in purée form, pudding, boiled or steamed fish, buttered rusks, cream crackers or thin crustless white bread, strained orange or tomato juice as a source of vitamin C, marmite as a source of the vitamin B complex, and cod-liver oil and malt or one of the concentrates of vitamins A and D. Between feeds sips of water, glucose solution, or half-strength isotonic saline were allowed in amounts up to 5 ounces an hour. The total fluid intake averaged about 2,750 c.c. a day. Except in cases in which there was epigastric pain, alkalis were deliberately avoided. No medication was given other than liquid paraffin or paraffin emulsions. Purgatives

were not allowed and, to avoid disturbing the patient, enemas were postponed to between the fifth and tenth days. The series consisted of 27 consecutive cases of which 25 did well; 24 of these received the above treatment and one received Lenhartz's treatment by initial starvation and ladder diet (see DIET IN TREATMENT, Vol. IV, p. 47). The other two patients died, one within six hours of admission and the other, who does not properly belong to this series, after operative treatment. *Results of treatment*

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HAEMATOCELE

See TESTIS AND CORD DISEASES

HAEMATOPORPHYRINURIA

SECTION 1

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1.—BIOCHEMICAL

583.] Before considering classifications and clinical manifestations of this condition it is advisable to give an account of the present position of the chemistry of haemoglobin and also of the porphyrins.

(1)—Types of Porphyrins

Strictly considered, 'haematoporphyrins', or porphyrins as they are called to-day, are the iron-free pigments derived from haemoglobin, haemochromogen, haematin, or haemin by the action of strong acids. The exact structure of these porphyrins depends on the conditions of preparation, but it appears that they are not synthesized in the human

body. Many porphyrins, such as haematoporphyrin, haemoporphyrin, protoporphyrin, and aetioporphyrin, have been prepared in the laboratory, and the interrelationships of these compounds and their connexions with the naturally occurring porphyrins have been worked out by the brilliant researches of Hans Fischer, Schumm, and their co-workers.

Classification and distribution of naturally occurring porphyrins

The naturally occurring porphyrins may be divided into two groups, according to their solubility in chloroform.

Group I. Insoluble in chloroform:

- (a) Coproporphyrin, found in normal faeces and yeast; (b) Uroporphyrin, occurring in the urine of patients with congenital porphyria; (c) Waldenström's porphyrin, extracted from pathological urines; (d) Turacin, the copper salt of a porphyrin occurring in bird feathers.

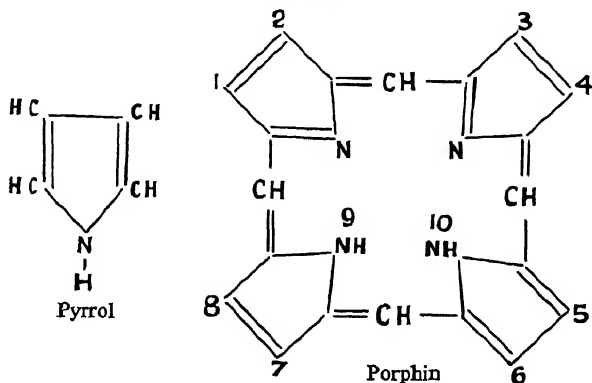
Group II. Soluble in chloroform:

- (a) Kämmerer's porphyrin, extracted from putrefying blood; (b) Papendieck's porphyrin, found in faeces after a meat meal; (c) Oöporphyrin, a pigment of certain egg-shells.

Fischer claimed that Kämmerer's porphyrin and oöporphyrin are identical with protoporphyrin. Oöporphyrin may be prepared by heating haematoporphyrin in a vacuum, when two molecules of water are lost. Waldenström's porphyrin was present in the urine of six cases of acute porphyria and one atypical case. It was partially precipitated by acetic acid and was soluble in ethyl acetate, methyl alcohol, and glacial acetic acid. Ether precipitated the porphyrin from solution in the last solvent. Turacin is regarded as the copper salt of uroporphyrin I. It has been shown that turacin differs from an iron porphyrin compound in not combining with nitrogen compounds and in not showing an oxidation-reduction effect.

Structural formulae

All porphyrins have a common structural skeleton, which has been shown by H. Fischer, Küster, and Schumm to consist of four pyrrole rings welded together into a complicated ring structure by four additional carbon atoms. This framework is porphin:



Drastic treatment resolves porphyrins into four pyrrol residues, the haemopyrrols, from a study of which the structure of the original porphyrins has been deduced. Synthesis from known pyrrol compounds has confirmed these structures.

Porphyrins are obtained from porphin by the substitution of groups in place of the hydrogen atoms numbered 1 to 8. Methyl groups replace four hydrogen atoms, while C_2H_5 , $CH=CH_2$, $CHOH.CH_3$, $CH_2.CH_2.COOH$, or $CH_2.CH(COOH)_2$, may replace the remaining hydrogen atoms. The following tables give the nature of the substituent side chains of the naturally occurring and artificial porphyrins and the probable positions of the substituent groups. In many cases a large number of isomerides are possible, and several of these have been synthesized by Fischer.

Relation of porphyrins to porphin

Isomers

PORPHYRIN	POSSIBLE NUMBER OF ISOMERS	SYNTHESIZED NUMBER	SIDE CHAINS
Aetioporphyrin	- 4	4	$4CH_3$, $4C_2H_5$
Uroporphyrin	- ..	..	$4CH_3$, $4CH_2.CH(COOH)_2$
Coproporphyrin	- ..	..	$4CH_3$, $4CH_2.CH_2.COOH$
Haematoporphyrin	15	2	$4CH_3$, $2CH_2.CH_2.COOH$, $2CHOH.CH_3$
Protoporphyrin	- 15	2	$4CH_3$, $2CH_2.CH_2.COOH$, $2CH:CH_2$
Mesoporphyrin	- 15	12	$4CH_3$, $2CH_2.CH_2.COOH$, $2C_2H_5$
Deuteroporphyrin	15	3	$4CH_3$, $2CH_2.CH_2.COOH$
Deuterohaemin	- 15	2	$4CH_3$, $2CH_2.CH_2.COOH$
Haemin	- 15	2	$4CH_3$, $2CH_2.CH_2.COOH$, $2CH:CH_2$

Probable Positions of Side Chains

Protoporphyrin	- 1.3.5.8	CH_3	2.4	$CH:CH_2$	6.7	$CH_2.CH_2.COOH$
Haematoporphyrin	1.3.5.8	CH_3	2.4	$CHOH.CH_3$	6.7	$CH_2.CH_2.COOH$
Deuteroporphyrin	1.3.5.8	CH_3	6.7	$CH_2.CH_2.COOH$		
Coproporphyrin	- 1.3.5.7	CH_3	2.4.6.8	$CH_2.CH_2.COOH$		
Uroporphyrin	- 1.3.5.7	CH_3	2.4.6.8	$CH_2.CH(COOH)_2$		

Aetioporphyrin may be considered to be the standard porphyrin and possesses great biochemical interest, because one isomer, aetio-porphyrin III, has been obtained from haemoglobin derivatives and from chlorophyll. The aetioporphyrins, which are the only porphyrins free from oxygen, exist in four forms:

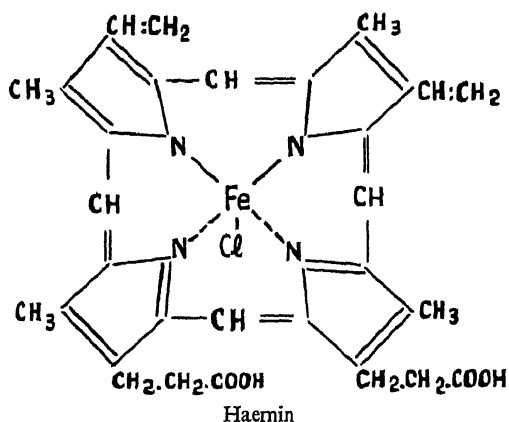
Aetio-porphyrin

Aetioporphyrin I	1.3.5.7	tetramethyl	- 2.4.6.8	tetraethylporphin
„ II	1.4.5.8	„	„	- 2.3.6.7 „ „ „
„ III	1.3.5.8	„	„	- 2.4.6.7 „ „ „
„ IV	1.4.6.7	„	„	- 2.3.5.8 „ „ „

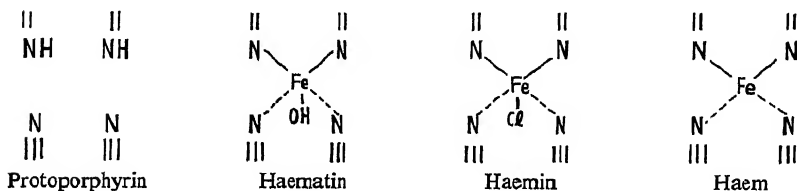
The porphyrins therefore fall into two main groups. The first group includes those derived from blood and chlorophyll, such as haemato-porphyrin and protoporphyrin. These have the four methyl groups in the 1.3.5.8 position, and aetioporphyrin III may be regarded as the parent substance. The second group, with methyl groups replacing hydrogen atoms in the 1.3.5.7 positions, include coproporphyrin and uroporphyrin. These are derived from aetioporphyrin I. In view of the structural difference between the two series, Fischer considered it unlikely that a member of one group might change into a member of the other.

Metallo-porphyrins

In the metallo-porphyrins the metallic constituent replaces the hydrogen atoms numbered 9 and 10. These substances demonstrate the close relationship between haemoglobin and porphyrins. The porphyrin which exists in haemoglobin is protoporphyrin. Haem is the divalent iron compound of protoporphyrin; it is oxidized by atmospheric oxygen to haematin, which forms a crystalline chloride, haemin. Haemin, which is readily obtained from haemoglobin by heating blood with glacial acetic acid and a chloride, has been synthesized by Fischer:



As regards only the centre portion of the molecule these compounds are related as follows:

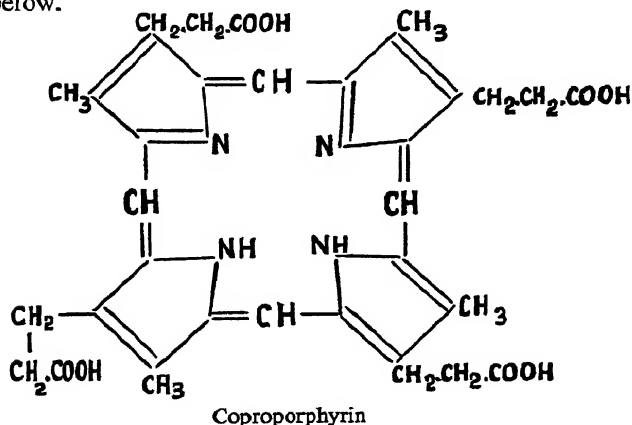


The following series of changes is of interest in view of the fact that haemoglobin = globin + porphyrin + iron.

	STATE OF IRON IN MOLECULE
Reduced haemoglobin	Ferrous
↓ + alkali (denatured globin)	
Haemochromogen	Ferrous
↓ alkaline oxidation (denatured globin liberated)	
Haematin	Ferric
↓ + HCl	
Haemin	Ferric
↓ glacial acetic acid + hydrogen bromide	
Haematoporphyrin	Absent
↓ Heat to 105° C.	
Protoporphyrin	Absent

Haematoporphyrin is a dark violet powder, almost insoluble in water but soluble in alcohol, strong acids, and alkalis. When it is heated to 105° C. *in vacuo*, water is lost and protoporphyrin is formed. The CHOH.CH_3 side chains change to $-\text{CH}=\text{CH}_2$ in protoporphyrin. Reduction of haematoporphyrin with hydriodic acid and acetic acid yields mesoporphyrin, in which two oxygen atoms have been lost, the CHOH.CH_3 side chains becoming $\text{CH}_2.\text{CH}_3$. Reduction with methyl alcohol, potassium, and pyridine produces haemoporphyrin, which when heated with soda-lime loses carbon dioxide, giving aetioporphyrin III. These changes show that this series of porphyrins are of the 1.3.5.8 tetramethyl type.

The similarity of coproporphyrin and uroporphyrin is demonstrated by the conversion of uroporphyrin into coproporphyrin by heating to 180° C. for several hours with dilute hydrochloric acid, carbon dioxide being lost in the process. The formula of coproporphyrin is given below.



In congenital porphyria or porphyria resulting from sulphone intoxication coproporphyrin I and uroporphyrin I have been detected in the excreta. Coproporphyrin III has also been detected in the urine and faeces of a patient with porphyria. Coproporphyrin I normally occurs in faeces to a small extent and has been detected in yeast.

(2)—Tests for Porphyrins

*Porphyrins
found in urine*

The porphyrins which are likely to be found in urine are uroporphyrin, coproporphyrin, and Waldenström's porphyrin. Protoporphyrin has been observed in one case by Waldenström. Normal urine contains coproporphyrin in quantity insufficient to affect the colour of the specimen or to yield absorption bands. When present in pathological quantity porphyrin colours the urine from port-wine to almost black.

Chromogen

The pigment may be present as a colourless chromogen, porphyrinogen, and for this reason the specimen should be exposed to sunlight before being tested. Potassium permanganate converts porphyrinogen into porphyrin more rapidly.

(a) General Tests for the Detection of Porphyrin in Urine

Spectroscopic examination

The urine is examined directly with the spectroscope. Porphyrin is excreted as alkaline porphyrin, characterized by four absorption bands. Sometimes the so-called metallic spectrum, resembling that of oxy-haemoglobin, is found. The alkaline porphyrin spectrum is still given after the addition of acetic acid. The specimen is now strongly acidified with hydrochloric acid. The two main absorption bands of acid porphyrin, a narrow one in the red part of the spectrum and a broad band in the yellow-green region, are given in the presence of the pigment. Small quantities are not detected unless a thick layer of urine is examined. Günther considered the appearance of an acid porphyrin spectrum in a two-inch layer of urine to be pathological.

Garrod's test

To 100 c.c. of urine add about 20 c.c. of a 10 per cent solution of potassium hydroxide. The precipitate of earthy phosphates carries down the adherent porphyrins. The precipitate is filtered off, washed, and extracted with warm alcohol acidified with hydrochloric acid. The filtrate is examined spectroscopically for the bands of acid porphyrin.

Acetic acid test

Add 5 c.c. of glacial acetic acid to 100 c.c. of urine. After forty-eight hours porphyrin deposits in the form of a precipitate. Waldenström stated that it was important not to add too much acetic acid, and, when the amount of porphyrin was small after twelve hours, suggested dilution of the urine with an equal quantity of water, which might materially increase the quantity of precipitate.

Waldenström's colour test

This is characteristic of porphyrins and is given by uroporphyrin, coproporphyrin, and protoporphyrin.

The precipitate from the acetic acid test is collected by centrifuging, and dissolved directly in concentrated hydrochloric acid. The colour is dark red. Add one drop of fresh 3 per cent hydrogen peroxide solution for every cubic centimetre of acid. The colour changes from red via yellow to dark green in the course of ten to fifteen minutes. After several hours the solution becomes colourless. When this change is followed in the spectroscope, a band appears in the blue part of the spectrum (4500–4600 Ångstrom units), increasing in intensity as the solution becomes more yellow. The porphyrin bands disappear, and when the solution becomes green a band in the extreme red (7150–6850 Ångstrom units) appears.

Photochemical reaction

When the urine containing porphyrin is exposed to filtered ultra-violet rays, a beautiful pink fluorescence is seen.

(b) Test for Coproporphyrin

The urine is acidified with acetic acid and extracted with ether. Separate the ether extract and shake with a small quantity of 25 per cent hydrochloric acid. The coproporphyrin is extracted with a fresh quantity of ether after neutralization of the hydrochloric acid with sodium acetate, using Congo red as indicator. The ether extract is separated and shaken several times successively with 0.1, 0.2, 0.3, 0.5, 1, and 3 per cent hydrochloric acid. This dissolves the coproporphyrin, and the acid extract is examined spectroscopically for absorption bands.

(c) Test for Waldenström's Porphyrin

After removal of coproporphyrin the urine is treated with more acetic acid and extracted with acetic ether. The acetic ether is shaken with 25 per cent hydrochloric acid, which dissolves the porphyrin. Examine spectroscopically. The precipitated porphyrin in the urine is separated and its solubility tested in methyl alcohol and glacial acetic acid. Uroporphyrin does not dissolve; Waldenström's porphyrin is soluble in these solvents.

(d) Test for Other Porphyrins

After removal of coproporphyrin and extraction with ethyl acetate, the porphyrin precipitate is filtered off and dissolved in decinormal sodium hydroxide. Add glacial acetic acid and extract with ethyl acetate (Waldenström's porphyrin). Any precipitate is filtered off. These fractions should be esterified and the esters examined spectroscopically. The urine may still contain porphyrin, which is precipitated by saturation with ammonium sulphate.

(e) Tests for Related Substances Occurring in Porphyrinuria

Ehrlich's aldehyde test and Schlesinger's fluorescence reaction should be performed. Positive results occur with Ehrlich's aldehyde reaction in red-coloured urines when Schlesinger's reaction for urobilin is negative. This is probably due to urofusin. Urines containing this red substance respond to the so-called urocarmin reaction of Fearon and Thompson.

Add two drops of 3 per cent hydrogen peroxide and 10 c.c. of concentrated hydrochloric acid to 2 c.c. of urine. A red colour is positive.

*Urocarmin
reaction*

(f) Wave-Lengths of Absorption Bands

	NUMBER OF BANDS	WAVE-LENGTH IN ÅNGSTROM UNITS	SOLVENT
Acid protoporphyrin —	— 2 or 3	6000, 5740?, 5540	
Alkaline protoporphyrin	— 4	6220, 5760, 5390, 5040	
Acid uroporphyrin —	— 3	5960, 5770, 5530	20% HCl
Alkaline uroporphyrin	— 4 or 5	6100, 5720?, 5580, 5375, 5020	N/10 KOH
Acid coproporphyrin	— 3	5920, 5700, 5480	20% HCl
Alkaline coproporphyrin	— 4	6170, 5690, 5380, 5020	N/10 KOH

2.—CLINICAL

Definition 584.] By definition haematoporphyrinuria is taken to mean a clinical condition in which porphyrins appear in the urine. They may be present either temporarily or throughout the whole of life. It is not necessary that sufficient of the pigment should be present in the urine to render it coloured to the naked eye, and in many cases the condition can only be discovered by careful chemical analysis combined with spectroscopic examination. The following classification serves as a suitable one, since it covers most of the common types: (1) haematoporphyrin congenita, (2) haematoporphyrin acuta, and (3) haematoporphyrin chronica.

(1)—Haematoporphyrin Congenita*Historical*

This condition was first described by Hans Günther, and, as A. E. Garrod suggested, it is only fair to maintain this title. Since Günther's original publication many cases have been reviewed, and an excellent summary was given by Garrod. A careful study of all the recorded cases supports the view that this is a definite inborn error of metabolism or 'chemical malformation'. In so far as it is possible to ascertain, all the cases fulfil the conditions necessary for the establishment of the diagnosis of inborn error. The greater difficulty, however, has been found in proving that the condition was truly present since birth. Garrod described one case in which the mother maintained that the very first urine passed was red and that the child had passed red urine ever since. In Günther's original case the red colour of the urine was noticed at the age of twenty months: his other patients stated that their urine had been red as long as they could remember.

*Age
incidence*

The outstanding clinical stigmata of the disease are the colour of the urine and the development of a skin eruption known as hydroa vaccini-forme. In many of the original cases the skin lesions were so disfiguring that a diagnosis of congenital syphilis was made. The skin lesion occurs

Clinical picture

on those portions of skin exposed to sunlight, namely, the face, neck, and backs of the hands, and, in the young, the knees. Its earliest manifestation is the appearance of bullae of various sizes containing either colourless or blood-stained fluids. On healing these leave permanent scars, and if infection takes place very severe disfigurement may result. In some cases amputation of the fingers has had to be performed. Occasionally bullae may appear on the conjunctivae, and this event is usually followed by the complete destruction of both eye-balls. The skin shows deep brown pigmentation in cases of long standing. Not all patients with haematoporphyria congenita are attacked by the skin condition; it appears to be less intense in men than in women.

Skin lesions

Another clinical manifestation is the deposit of deep brown pigment in the bones. This renders the bones of the hand, for example, visible on transillumination. This again is not found in every case. In some cases pigmentation of the enamel of the milk-teeth appears. In one of Garrod's cases the child cut a tooth at the age of nine months, and this was definitely pink. At twenty-two months the child had twelve teeth, all of which were of a pinkish-red colour indistinguishable from that of the gums.

Pigmentation of bones and teeth

Of other clinical manifestations the concomitant infection with tuberculosis appears to be important. The review of a large series of cases convinced Garrod that patients with haematoporphyria congenita were specially liable to this disease.

Association with tuberculosis

Apart from the above-mentioned conditions there appears to be little else which can be found in the clinical examination of such patients. In later life enlargement of the spleen appears to be common, and in some cases enlargement of the liver has been described: this has led to the belief that the cause of the disease lies in some faulty functioning of this organ, and there also appears to be a certain amount of experimental evidence to support this.

Enlargement of liver and spleen

The cause of the skin lesion appears to be the sensitization of the surface of the body to the action of ultra-violet rays. This thesis finds considerable support in experimental work. It has been known for many years that the presence of fluorescent pigments increases sensitivity to light in lower organisms such as the paramecium. Hausmann showed that the injection of haematoporphyrin into the higher animals had the same effect. Thus the injection of 0.01 gram of haematoporphyrin into a white mouse will not cause any change in the animal if it is kept in the dark; exposure to bright light, however, will result in the death of the animal in a few hours. Similar experiments were performed on the human subject by Meyer-Betz. This worker injected 0.2 gram of haematoporphyrin intravenously into himself. Shortly after the injection he irradiated the skin of his arm with ultra-violet rays for forty minutes.

Sensitivity of skin to light

The reaction of a normal person to such irradiation resulted in a trivial local lesion such as a blister. In the case of the sensitized individual, however, a very severe lesion developed within twelve hours, the skin becoming indurated and oedematous, and later superficial necrosis and blackening of the area occurred. Exposure of the face to sunlight produced giant oedema. The experimenter remained in this sensitive condition for some three months.

The method of examining the urine in these cases has been dealt with already (see p. 90).

Prognosis

With regard to the prognosis, since the lesion is due to an inborn error of metabolism there is no known method of treating it, and therefore the patient's condition depends entirely on how careful he can be to avoid exposure to sunlight.

(2)—Haematoporphyria Acuta

Mortality

This condition is associated with very severe pain in the lower abdomen together with peripheral neuritis; symptoms of bulbar paralysis may supervene. The mortality is very high. The urine in many cases appears dark red or black and contains considerable quantities of porphyrin.

Clinical picture

It is interesting to note that there is no sensitization to light. An excellent review of this condition was given by Waldenström. The typical history appears always to start with an acute abdominal attack, and in many cases laparotomy has been performed. In those cases in which the abdomen has been opened very vigorous peristalsis has been observed, but no other sign has been found. In all the recorded cases there was no history that pigmented urine had been passed before the attack. The abdominal pain appears to be concentrated in the lower section of the abdomen and is described as of a violent colicky nature.

Pain

Neuritis

The neuritic symptoms usually start in the form of radiating pains of a sharp stabbing character from the lower part of the abdomen, shooting down the legs and into the arms: wrist-drop and ankle-drop may develop. Alterations in the sensibility to pain have been noticed on the trunk, and, as has already been pointed out, bulbar paralysis with death from respiratory failure is a common termination.

Morbid anatomy

At necropsy the most characteristic changes are found in the nerve sheaths, the myelin having almost completely disappeared; oedema or a granular exudate occurs round the nerves, and there appears to be proliferation of the connective tissue of the perineurium. In the spinal cord there appears to be a change in the cells of the anterior horns, particularly in the cervical region.

Urine

The urine, as already pointed out, is dark red and may be almost black, the colour being due to the presence of porphyrins. In those cases in which recovery takes place the urine gradually returns to normal colour, and the porphyrin content is reduced in a period of three to four weeks. The substance present is either coproporphyrin or uroporphyrin. In some cases Waldenström described the appearance of a new porphyrin which differed from the known porphyrins in that it was

not completely precipitated by acetic acid, and it also differed in its solubility and absorption spectra. Waldenström also described some special tests which might well be applied in these cases.

Nothing is known with regard to the aetiology of this condition, and there are not a sufficient number of cases described upon which to venture opinions as to prognosis or treatment. *Aetiology and prognosis*

(3)—Haematoporphyria Chronica

This condition is produced by the prolonged administration of certain drugs of the barbituric acid series, of which sulphonmethane, phenobarbitone, and the like are examples. In this condition haematoporphyria and light sensitization have been described. The condition can occur with ordinary therapeutic doses, especially if they are continued for some time. After prolonged administration a chronic poisoning may show itself by the appearance of nervous depression, gastro-intestinal disturbances, and the appearance of porphyrin in the urine. This is shown by the gradual darkening of the colour of the urine from day to day until finally dark red fluid is passed. It is at this stage that light sensitization occurs. Even if the administration of the drug is discontinued at an early stage, recovery is very slow. In most cases the appearance of haematoporphyria is the sign of a very bad prognosis, and death usually occurs in a few weeks from general exhaustion. *Causes* *Prognosis*

The treatment consists in withholding barbiturates and administering suitable remedies for the secondary complications, such as exhaustion. *Treatment*

Haematoporphyrinuria has been described in a very wide series of cases; in many instances it is difficult to be certain that sufficiently accurate spectroscopic analyses were made, and it is therefore proposed not to review this literature. Full references to the occurrence of haematoporphyrinuria will be found in Wells' *Chemical Pathology*, 5th edition, London. *Conclusion*

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HAEMATURIA

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Reference may also be made to the following titles:

BILHARZIASIS	KIDNEY, SURGICAL
BLADDER DISEASES	DISEASES
ENDOSCOPY OF THE	NEPHRITIS AND NEPHROSIS
URINARY TRACT	PYELITIS
HAEMORRHAGIC DISEASES	URINE EXAMINATION

I.—HAEMATURIA

1.—INTRODUCTION

585.] Haematuria, the presence of blood in the urine, is not in itself a disease, but is a 'sign' which is found in a large number of different conditions, and varies greatly in significance according to the underlying cause. The blood varies much in amount, from the most severe haemorrhage with urine of a dark port-wine colour, or even containing clot, to an amount so small that the ordinary chemical tests fail to detect it, and it can only be proved by microscopical examination. There is then no evidence to the naked eye that blood is present and it may be easily overlooked. When somewhat larger amounts are present, the urine begins to appear 'smoky' and has a characteristic greyish haze to transmitted light. With a further increase the typical red colour of oxyhaemoglobin is seen, deepening with the presence of more and more blood to a deep port-wine or even red-black colour. The condition must be clearly differentiated from haemoglobinuria, in which blood pigment only is present. The discovery of the red cells under the microscope settles the matter.

*Haemo-
globinuria*

*Variations in
course of
haematuria*

The presence of red blood cells in the urine may be the first indication of something wrong; or the haematuria may come on in the course of some already recognized disease. It may follow an attack of pain or be entirely painless; or it may be painless at first and then become painful. There may be no difficulty in micturition, or such difficulty may develop later, as the result for instance of superadded sepsis or clot retention. The haematuria may be slight at first and become severe; or it may be so severe from the onset as to imperil life; or it may by repetition produce severe anaemia. The progress of cases varies; for example, slight haemorrhage may cease spontaneously or there may be a long interval and then a recurrence.

2.—AETIOLOGY

*Sites of
haemorrhage*

Haemorrhage may occur in any part of the urinary tract from the renal glomeruli to the urinary meatus; but, as the organ from which the haemorrhage comes in any particular case may at first be very difficult to identify, an anatomical classification is not very practicable. It is absolutely essential to make an examination of the urine microscopically in every case of haematuria; the findings will often point the way to the further investigation of the case. The investigations necessary to substantiate the diagnosis in any particular case are given in the articles dealing with the underlying conditions.

The presence of casts is diagnostic, because they must come from the kidney and therefore point to the great probability that the haemorrhage

also originates from that organ. The presence of pus is also of great value because it indicates that the haemorrhage is accompanying some septic condition. The presence of malignant cells shows new growth as the cause of the haemorrhage. Finally in many cases the haemorrhage is unaccompanied by any other cells.

*Significance
of other
urinary
abnormalities*

3.—CLASSIFICATION

The cases can be classified in four groups: (1) Haematuria with casts. (2) Haematuria with pus. (3) Haematuria with malignant cells. (4) Simple haematuria without additional deposit.

Albumin must necessarily be present in urine when blood is in it, but in many conditions it occurs in an amount much greater than that brought in by the blood. It is then of considerable help in differentiating the condition present, making it almost certain that the case falls into Group (1) or (2).

Albumin

(1)—Haematuria with Casts

The occurrence of casts in the urine in small numbers is not of great significance, but when they are present in conjunction with red blood-cells a grave condition of the kidney can be inferred.

(a) *Acute Nephritis*

Acute nephritis is one of the commonest diseases in which blood is present in quantity in urine. Casts always accompany this and are usually present in great quantity; they are of many kinds, hyaline, granular, and cellular; some may be composed almost entirely of red cells. The cellular forms also contain polymorphonuclear leucocytes and renal cells, the former being numerous in the earlier stages, the latter becoming more frequent later. In the earlier stages leucocytes are also found free in the urinary deposit.

Casts

The amount of blood present varies greatly, the colour ranging from deep port-wine to a faint smoke-like haze. The amount present is to some extent correlated with the severity of the attack, but a much better indication of this is the amount of urine passed in twenty-four hours; oliguria is of more significance than the intensity of the haematuria. The amount of albumin present, when the haematuria is not so intense as to dominate the picture completely, is much in excess of that due to the blood.

*Oliguria
Albumin*

The blood in acute nephritis comes from the glomeruli; these are acutely swollen, with hyaline degeneration of their capillaries and much desquamation of their lining cells, which are found packed together in the space in which the glomerulus lies. The red-cell casts are formed subsequently during the passage of the blood through the tubules. Haematuria often persists for many weeks, and does not necessarily imply lack of improvement in the patient's condition.

*Source of
blood*

*(b) Subacute Nephritis**Albumin and casts*

Subacute nephritis (the large white kidney) may also be accompanied by haematuria. This is usually slight and never dominates the picture. The blood may give rise to a visible smokiness or may only be identified under the microscope. The presence of albumin in large quantity and casts of every variety, together with the clinical condition, substantiates the diagnosis.

(c) Chronic Nephritis

Chronic nephritis, the secondary contracted or small white kidney in which the great destruction of the kidney tissue has been followed by uniform fibrosis, may also show haematuria when renal failure begins to take place. It is usually of slight degree and accompanied by a rise in the albumin content and a diminution of the urinary output. In these later stages of nephritis haematuria is probably due to a direct leak into the tubules owing to the disorganization of the kidney substance.

*(d) Embolic Focal Nephritis**Association with malignant endocarditis*

Embolic focal nephritis, which was first clearly differentiated by Löhlein as a special type of kidney change, is always associated with malignant endocarditis. It can conveniently be included here, although casts may often be absent, and are never present in great quantity. Haematuria is constantly present but is usually extremely slight; it is not shown by the ordinary chemical tests and does not give definite smokiness to the urine, being proved only by microscopical examination. The amount of albumin in the urine is also slight, being not much in excess of that due to the blood present. The haematuria is very persistent, lasting for weeks or even months if the patient survives. The blood comes from the glomeruli. Small emboli from the diseased valve block the capillaries in some tufts and cause small local foci of infection which never involve more than a small part of the affected glomerulus. The uninvolved, unchanged part continues to expand and contract with the pulse beat, and haemorrhage takes place at the margin between the fixed inflamed portion and the free normal remainder. The secondary fibrosis which follows does not alter the mechanical condition and small leaks continue to occur. The presence of this slight haematuria is often of value in clinching the diagnosis of malignant endocarditis.

*Source of the blood**(e) Hyperpiesia*

The kidney of hyperpiesia, which can also be called the high-pressure arteriosclerotic kidney or the primary contracted kidney, the condition most commonly meant by the vague term chronic interstitial nephritis, may also show haematuria in the stage when the cardiovascular system is beginning to fail. The kidney changes are here secondary to the arteriosclerosis of the smaller arteries of the organ, the interlobulares and afferentes. The differential diagnosis between this condition and

true chronic nephritis is often extremely difficult; the amount of haematuria which may occur is very similar in both and does not help in the differentiation. Casts are always present also, but neither their number nor their nature is of much diagnostic assistance. *Similarity to chronic nephritis*

(2)—Haematuria with Pus

(a) Calculus

Renal calculus is the commonest condition associated with the combination of haematuria with pus, and the relative proportions of the blood and pus present vary greatly. They are, however, seldom excessive in amount, and the haematuria does not often produce more than a pronounced smokiness in the urine. The symptoms and the X-ray examination substantiate the diagnosis. *Renal*

Ureteral calculus also causes a similar haematuria, the diagnosis being made by radiography. *Ureteral*

(b) Acute Pyelitis and Pyelonephritis

Acute pyelitis and pyelonephritis may occasionally be associated with some blood in the urine, red blood-cells being found microscopically in the deposit. An amount of blood which is visible to the naked eye almost always implies the presence of a calculus in association with the purulent condition of the renal pelvis. Coliform bacilli are usually found in cases of pyelitis.

(c) Tuberculosis

Tuberculosis of the kidney and bladder is another common cause of blood and pus in the urine. The urine may be sterile, and the haematuria, perhaps slight, sometimes precedes any other symptoms of the tuberculous infection. The presence of tubercle bacilli establishes the diagnosis but is often difficult to demonstrate. In many cases of renal tuberculosis a coliform bacillus infection is superadded, and the primary tuberculous infection may therefore be overlooked. Haematuria in the absence of a calculus is a most valuable indication that tuberculosis may be present in addition to the coliform infection. Cystoscopic and X-ray examinations usually settle the matter when tubercle bacilli cannot be found. The cystoscope shows tubercles around the orifices of the ureters with inflammation of the bladder wall, from which the haemorrhage usually comes. *Superadded coliform bacillus infection*

(d) Acute Cystitis

Acute cystitis may give rise to a very considerable haematuria associated with foul-smelling pus. Even in the mildest cases blood is almost always present microscopically in the earlier stages. The alkaline condition of the urine and the frequent painful micturition sufficiently differentiate this condition. *Cystoscopic confirmation*

(e) Stone in the Bladder

Stone in the bladder if of long duration, especially if catheterization has been necessary, is almost certain to give rise to a cystitis. The occur-

rence of haematuria, especially if the blood is considerable in amount and appears intermittently, should arouse the suspicion that stone is also present.

(3)—Haematuria with Malignant Cells

Cells which can be definitely identified as malignant prove the presence of malignant disease in the urinary tract. Often, however, either no cells suggesting a neoplasm can be found, or their shape and condition are such as to leave their identification doubtful. A simple haematuria with perhaps some cellular excess is then all that is found.

*Hyper-
nephroma
of kidney*

Hypernephroma of the kidney in its later stages may give rise to a haematuria which is usually severe. It is often the first symptom of the condition and is painless. Cystoscopic examination shows it to be unilateral. It varies in amount from day to day. This tumour grows towards the pelvis of the kidney and spreads directly along the renal veins. It is extremely liable to haemorrhagic necrosis, and the haemorrhage into the urine arises from these pelvic downgrowths.

*Sarcoma of
kidney*

Sarcoma of the kidney, which occurs almost exclusively in children, also causes haematuria.

*Carcinoma
of bladder*

Carcinoma of the bladder gives rise to what may be severe haematuria. It is intermittent at first but later practically constant, though varying considerably in amount. The greatest concentration of blood is usually passed at the end of the act of micturition. Malignant cells can often be found, but are not of such diagnostic importance as in hypernephroma because cystoscopic examination reveals the condition at once.

*Sarcoma of
bladder*

Sarcoma of the bladder gives rise sooner or later to a similar form of haematuria at first intermittent. It may be the only sign of the disease.

*Carcinoma
of prostate*

Carcinoma of the prostate is often accompanied by haematuria. This is of the urethral type, sometimes even occurring without the passage of urine; when passed with the urine the blood appears mainly at the beginning of micturition and is irregularly mixed. When present it is often a valuable sign for differentiating malignant enlargement from simple hypertrophy. In rare cases, however, benign enlargement of the prostate may also cause haematuria of the urethral type. This is usually much slighter in degree, unless due to gross damage by a catheter.

*Benign
enlargement*

*Carcinoma
of urethra*

Carcinoma of the urethra can also give rise to haematuria.

(4)—Simple Haematuria without Additional Deposit

*Papilloma
of bladder*

Papilloma of the bladder is one of the commonest causes of painless, symptomless haematuria. The haematuria is intermittent and varies in amount but is often severe, with dark red urine. Cystoscopic examination reveals the condition.

*Papillomas
of pelvis of
kidney*

Villous papillomas of the pelvis of the kidney also cause haematuria. The condition is rare and the enlargement of the kidney is not great. The diagnosis is obtained by pyelography, after cystoscopy has revealed the unilateral nature of the haematuria.

Stone

Stone in the bladder in the early stages may give rise to an intermittent

haematuria which is simple and not accompanied by pus. The bleeding arises from injury to the bladder wall.

Prostatic calculi formed by the deposit of mineral salts on prostatic concretions may give rise to haemorrhage of the urethral type, blood being most concentrated at the beginning of micturition. *Prostatic calculi*

Urethral caruncle is a cause of haematuria in the female, the source of the bleeding being small vascular excrescences which may be the homologues of the prostate in the male. Bleeding is of the urethral type. *Urethral caruncle*

Urethral polypi occasionally occur in the male and give rise to haematuria. *Urethral polypi*

Angiomas of the bladder or urethra are a rare cause of simple haematuria. Varicose veins at the base of the bladder may also be a cause. *Angiomas and varicose veins*

Diseases of the blood and blood-vessels also cause haematuria.

Purpura in its more grave forms may give rise to bleeding from the kidney as well as from other mucous surfaces. Other sites of haemorrhage are almost always present. *Purpura*

Acute lymphoid leukaemia may be accompanied by severe haematuria lasting for many days. In some cases this is the outstanding symptom. The blood count and the condition of the gums prove the nature of the disease. *Acute lymphoid leukaemia*

Acute aplastic anaemia also may be associated with haematuria. The examination of the blood and the very grave clinical condition give the diagnosis. *Acute aplastic anaemia*

Haematuria is sometimes prominent in infantile scurvy.

Scurvy

Bilharzial infection is the commonest cause of haematuria in some tropical countries (endemic haematuria), especially in Egypt. The infecting ova burrow into the veins and wall of the bladder and cause a haematuria which may continue for years and produce great debility. Detection of the ova in the urine proves the nature of the disease. (See also BILHARZIASIS, Vol. II, p. 326.) *Bilharziasis*

Certain drugs, such as oil of turpentine, cantharides, and hexamine, if taken in excessive doses, may cause haematuria as a result of the great damage they cause to the kidney. *Drugs*

Traumatic damage to any part of the urinary tract may give rise to an haematuria. *Trauma*

II.—ESSENTIAL HAEMATURIA

586.] In some cases all the above causes of haematuria can be eliminated, all investigations proving completely negative. These cases have been grouped together under the name essential haematuria. *Definition*

Hale White in 1911 collected and reviewed all the known literature concerned with this condition, and more recently Wheeler, and Wilbur and Priestley have brought the evidence up to date. Most of the records concern single cases, but Wilbur and Priestley have examined a series

*Morbid
changes in
kidney*

of no less than 100. In a number of cases nephrectomy has been done, and it has therefore been possible to study the kidney macroscopically and microscopically. All authorities agree that if any changes can be definitely associated with the condition they are extremely slight. Earlier views that some form of mild toxic nephritis is responsible for the condition are rejected by the authors quoted above. The cortex and medulla of the kidney are absolutely normal, the tips of the papillae being the only place in which changes have been described.

In the ten of Wilbur and Priestley's cases in which a histological examination was possible vascular changes in the form of dilated venules and interstitial haemorrhage, often with excessive inflammatory fibrosis, could be demonstrated. In a series of five cases Wheeler described similar changes in the tips of one or more of the papillae. In earlier cases, in which no changes were found, the examination of the papillae was not sufficiently thorough to refute this evidence, so that the present position is that slight vascular changes at the tips of the papillae are probably the cause of the condition.

*Clinical
picture*

Clinically the bleeding varies very greatly in duration, from a day to a year; but sixty of Wilbur and Priestley's cases bled for less than a month. The haematuria is usually painless, but in a small percentage of cases mild pain in the renal region is associated with it. In those cases in which pain of a severe character, almost amounting to renal colic, has been observed, this is probably due to the passage of an ureteral clot. The bleeding, though prolonged, is seldom so severe as to endanger life; nephrectomy is therefore usually unjustified, although it has fairly often been done for the condition. Bleeding tends to recur after a varying interval, and, though cystoscopy shows that it is almost always unilateral, it may occasionally recur on the opposite side; this happened in two cases treated by nephrectomy in Wilbur and Priestley's series. Very rarely haemorrhage is bilateral.

Diagnosis

In order to establish the diagnosis, which is one of exclusion, all possible methods of examination must be used, and a final negative retrograde pyelogram must give rise to strong suspicions that essential haematuria is the correct diagnosis. A second negative pyelogram six months later makes the diagnosis almost certain, for any small tumour that may have been overlooked would by then have increased sufficiently to be recognized.

Treatment

Treatment has until lately consisted of exploratory operation with either decapsulation or nephrotomy when nephrectomy has not been done. The results have been very satisfactory at any rate for some time after operation. Hale White watched his cases for two to three years without recurrence taking place. It has been suggested that some interference with the sympathetic nerve-supply to the vessels may cause this amelioration. Wilbur and Priestley, however, hold that such surgical interference is unjustifiable, and that equally good results can be obtained from irrigation of the renal pelvis with silver nitrate solution of 1 to 5 per cent. Such irrigation may stop the bleeding immediately,

but often has to be repeated a few times before the haemorrhage ceases.

They also emphasize an association with focal infection of the upper respiratory tract, exacerbations of such infections often synchronizing with the onset of the haematuria. They believe that in some unexplained way the one produces the other, and therefore state that a most important part of treatment is the removal of all such foci. Medical treatment is useless and has never been shown to have the slightest effect on the condition.

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HAEMOCHROMATOSIS

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Reference may also be made to the following titles:

DIABETES MELLITUS

LIVER DISEASES

1.—DEFINITION

Synonyms

587.] In the past this disease has been described under various names, but the only alternatives to the title haemochromatosis which now survive are (*a*) pigment cirrhosis (Troisier, 1871), and (*b*) bronze diabetes (Hanot and Schachmann, 1886).

Its essential features consist in cirrhosis of the liver and, to a much less extent, of other organs, and in deposition of pigments in nearly all the tissues of the body. There is a profound disturbance of the metabolism of iron, resulting in the production of the pigment haemosiderin, and a parallel disturbance of metabolism, probably of protein, which results in the production of the melanin pigment haemofuscin. These changes

lead in time to a characteristic clinical picture in which pigmentation, diabetes mellitus, hepatic cirrhosis, and endocrine changes are the most prominent features.

2.—AETIOLOGY

Haemochromatosis has a sharply limited incidence, both of age and sex. *Age incidence*
The earliest recorded age is twenty years, and thereafter there is a gradually increasing liability until the decade forty-five to fifty-five is reached, when the incidence is at a maximum—42 per cent of the recorded cases occurred during these ten years. There is then a rapid decline in incidence. These figures apply to the age of the established disease; in many cases it is found that one or more symptoms, particularly pigmentation, may date back much earlier. From a clinical point of view the disease is therefore one of middle life.

The sex incidence is even more sharply limited than the age, haemo- *Sex incidence*
chromatosis having an overwhelming incidence in males. Of 311 recorded cases, 295 occurred in men and 16 in women, giving a proportion of roughly 20 males to 1 female. For various reasons the true proportion is probably even greater than this. Apart from a few minor differences, particularly a tendency for the hepatic cirrhosis to be of the atrophic form in females, the disease has the same characters in both sexes.

A few familial and hereditary cases have been recorded and have a *Heredity*
special significance from the rarity of the disease. Lawrence described a family in which the transmission of the disease was thought to suggest a sex-linked inheritance.

An explanation of haemochromatosis involves the integration of a number of apparently isolated phenomena which are briefly indicated below. Among these there appear to be at least four which are primary and not derivative. These are: (i) the deposits of haemosiderin and haemofuscin, (ii) the age-incidence, (iii) the sex incidence, and (iv) the cirrhosis of the liver and other organs. Numerous hypotheses have been advanced in the past, but most of them, including that of chronic copper poisoning (Mallory), do not explain all the above features (Sheldon, 1935). The most satisfactory view is that the disease is an inborn error of metabolism, dating from conception but not becoming clinically obvious until middle life. The exact nature of this error is still unknown, but it concerns the inner metabolism of all the cells of the body and is shown in two ways: (i) by the production of a melanin pigment in certain situations, and (ii) by the formation of an iron-containing compound in nearly all the tissues. The latter is probably the result of some abnormality which gives the iron concerned in intracellular respiration a shorter life than normal and then leaves it in a form unfit for excretion. This error does not produce any disturbance of health, but it initiates in many organs a process of fibrosis, and eventually the characteristic symptoms of disease in the organs affected. In

the course of time the products of this error of metabolism accumulate as the characteristic pigments and ultimately lead to the final stage of the disease, the process being so slow that the symptoms usually do not appear till middle life. The sex incidence is probably explained by the mode of transmission of the error of metabolism which, as already mentioned, has been thought to be by sex-linked inheritance; but on this point further data are urgently needed.

3.—MORBID ANATOMY AND CHEMICAL PATHOLOGY

(1)—Morbid Anatomy

As every tissue in the body may be affected, a detailed description would be of undue length. The morbid changes may be grouped under the following headings: (*a*) pigment deposits, (*b*) fibrotic changes, and (*c*) degenerative changes.

(*a*) Pigment Deposits

Two pigments are found in the tissues, haemosiderin and haemofuscin, which in addition to their chemical differences also have a characteristic distribution in the tissues.

Haemosiderin

Distribution of pigment

Endocrine glands

Kidney and testis

Haemosiderin is a deep yellow pigment and consists of an organic basis impregnated with iron. Its iron content is high (55 per cent), and the metal appears to be in the form of a colloidal ferric oxide. This, the predominating pigment of haemochromatosis, has remarkably wide-spread distribution, the most prominent feature of which is the extreme tendency to affect gland cells. This applies to the glands of both external and internal secretion. The greatest amounts are found in the liver and pancreas, but every secreting gland may be affected; the pigment has even been found in the male breast. The epithelium of the excretory ducts may contain haemosiderin, but the amount is not large, and it is mainly confined to the smaller ducts. The endocrine organs are extensively affected. The parathyroids always contain pigment, and in some cases the amount is enormous. The thyroid is usually heavily pigmented. In the adrenals the zona glomerulosa is invariably pigmented, but the remainder of the gland usually escapes. The islands of Langerhans are pigmented in 80 per cent of the cases, the degree varying from fine grains of pigment up to large masses which have destroyed the islet. The anterior lobe of the pituitary is affected, but the posterior lobe usually escapes.

The kidney and the germinal epithelium of the testis stand in somewhat striking exception to this list. The kidney shows a moderate degree only of pigmentation, confined in most cases to the convoluted tubules of the second order, and the germinal epithelium of the testis usually escapes altogether. The total amount deposited in the kidney during life is probably greater than the microscopical appearances suggest, owing to desquamation of epithelium in the urine. Smooth muscle

practically never contains haemosiderin, but the striated musculature *Muscle* is affected to a far greater extent than has been recognized. The amount deposited appears to bear some relation to the degree of functional activity of the muscle, being, for instance, greater in the tongue than in the quadriceps. In keeping with this, the heart shows pigmentation *Heart* in at least 90 per cent of the cases, and the amount is sometimes enormous. It could hardly be expected that such huge deposits of pigment should occur in the body without the reticulo-endothelial system being *Endothelium* affected, and pigment is found in the Kupffer cells of the liver, in the spleen, and in the alveolar epithelium of the lung. The capillary endothelium is affected in most organs, but the pigmentation of this structure reaches a maximum in the testis, where the capillaries (and lymphatics) may be transformed into pipes of iron. In contrast to the above is the *Bone marrow* bone marrow, in which the amount of haemosiderin is slight.

In addition to the above sites, haemosiderin is also often present in *Other tissues* cartilage, both of joints and of the respiratory tract, and it may occur in the synovial endothelium of the joints to an extent sufficient to cause naked-eye pigmentation. Wherever there is much pigment in the true cells, there is nearly always pigmentation of the connective tissues, and this reaches a maximum in the liver and pancreas. In the former organ especially the amount of pigment in the fibrous tracts may overshadow that in the liver cells. All the lymphatic glands contain pigment, the amount depending on the region they drain. The portal and pancreatic glands in particular may be changed into masses of pigment which completely obliterate the normal structure.

Haemofuscin, in contrast to haemosiderin, is a dark, almost black, *Haemofuscin* pigment and does not contain iron. It contains sulphur and is probably related to the melanins. It is also either identical with, or closely related to, the 'brown' pigment of old age and atrophy. This pigment is mainly *Distribution in body* deposited in smooth muscle; the large amount and the constancy of its presence here are striking features of the disease. It affects especially the smooth muscle of the generative tract and the alimentary canal, where it is usually most intense in the duodenum and jejunum, though all parts may be affected; it shows an especial preference for the longitudinal muscle. It has been suggested (Thompson) that the distribution of the pigment in the alimentary canal may be related with the pH at the level concerned. The smooth muscle of the blood-vessels, particularly of the arteries, is also heavily pigmented, and in some cases the vessels can be traced by the naked eye to their small ramifications on account of their brown colour.

(b) *Fibrotic Changes*

Fibrosis of certain organs is as invariable as the pigmentation. Hepatic *Liver* cirrhosis is a constant feature of the disease and is usually of the hypertrophic type, the liver weighing up to 4,000 grams. Atrophic cirrhosis is very rare, being found in only some 7 per cent of the cases. The cirrhosis is slow in its progress. The pancreas is also constantly affected,

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and, although the degree is usually less than in the liver, the fibrosis may in some instances be extreme. In the liver the pigmentation and cirrhosis are usually of somewhat parallel intensity, but in the pancreas there may be a distinct separation between the two changes, and in some cases with a comparatively small amount of pigment the degree of cirrhosis has been extreme.

Other organs The spleen nearly always shows some fibrosis; this may also occur in the salivary glands, heart, and thyroid, but is rare in the remaining organs and does not appear to be related to the amount of pigment. Thus the parathyroids and choroid plexuses invariably have a high pigment content, but there is not any record of a fibrosis. On the other hand in the lymphatic glands, which are constantly affected, it appears that the degree of the fibrosis may go hand in hand with that of the pigmentation. It is clear that the fibrotic changes involve more than a pure cirrhosis of the liver, and it seems justifiable to use the term *hepatic polysclerosis* for this aspect of the disease.

(c) Degenerative Changes

The last is the least prominent feature and, apart from direct mechanical damage caused to various parenchymatous cells by their load of pigment, is practically confined to degenerative changes in the islands of Langerhans and in the germinal epithelium of the testes.

(2)—Biochemical Changes

Iron Chemical examination of the blood does not help in the diagnosis during life. The iron content of the blood appears to be somewhat less than normal, in contrast to the state of affairs in the tissues (Sachs, Levine, and Griffith). At necropsy the tissues show an astonishing series of chemical changes, storage of iron being the most prominent feature. The total amount of this metal deposited in the body appears to amount in severe cases to about 50 grams, and in less severe cases it reaches at least 20 grams. The amount of iron may therefore be increased tenfold above the normal, which is about 5 grams. Hardly any tissues appear to escape, though in some, such as the brain and colon, the increase, if present at all, is very small. The largest amounts are deposited in the glandular organs, such as the liver and pancreas, where the increase above normal may be as much as a hundredfold. Striated muscle contains about four times the normal amount of iron, and because of the great extent of this tissue the muscles come second to the liver in total content of iron. In addition to the increase of iron there appears to be a constant increase in calcium, which tends to follow in intensity the variations in iron, being greatest in the liver and pancreas.

Calcium There appears also to be some disturbance in the distribution of sodium and potassium, but this feature of the disease still awaits further investigation. The zinc content of the tissues is normal, but there appears to be a low manganese content, at any rate of the liver. The

Sodium and potassium

Zinc

Manganese

copper content of the tissues is increased, especially in the liver, and the average order of increase appears to be about twice the normal. This is also true of striated muscle. There is also some disturbance of sulphur metabolism, which appears to be related to the deposits of haemofuscin.

4.—CLINICAL PICTURE

The disease may first become manifest in various ways. Pigmentation is undoubtedly the commonest of these, and patients will often confess to having known they were of an unusual colour for many years before the appearance of other symptoms. This may sometimes date back as far as childhood. In the absence of other troubles, however, it is but rarely that patients consider this a symptom worthy of medical attention. Apart from the pigmentation, the commonest conditions for which the patient seeks relief are diabetes mellitus, abdominal symptoms due to the hepatic cirrhosis, and general lassitude. Once the disease has become clinically evident it is characterized by a tetrad of manifestations, namely (i) pigmentation, (ii) diabetes mellitus, (iii) cirrhosis of the liver, and (iv) endocrine symptoms. Myocardial symptoms are undoubtedly commoner than has been recognized in the past. Apart from the hepatic cirrhosis, which is invariable, any or all of these may be absent, though this state of affairs is rare. These manifestations may now be considered in greater detail.

Pigmentation is present in more than 80 per cent of cases. The abnormal colour has an even distribution where it is present on the body (i.e. it is not macular or in plaques) and is heaviest on the face, forearms, hands, and often most extreme in the region of the pudenda. The coloration may follow one of two types: (i) a distinctly bluish, bluish-grey, or leaden appearance, which in reflected light may strongly suggest a metallic comparison; this is especially apt to be found on the face; and (ii) a pure bronzing, progressing in severe cases through all shades of brown to black and having the same appearance as the pigmentation of Addison's disease; this colour is more apt to be found on the face, limbs, and genitalia. The same patient may show all degrees of mixture of these types, but the commonest appearance is for the face to be bluish and the body brownish. The blue colour is quite distinct from the blueness of cyanosis. The pigmentation of the body is subject to curious fluctuations in intensity. It often shows a marked decrease when diabetes mellitus has come under control with insulin, and it usually deepens considerably before death.

The mucous membranes accessible to ordinary clinical examination are pigmented in about 16 per cent of cases, and if the mucous membranes of the nasal cavity and of the larynx and epiglottis are included the proportion is much higher. Indeed the examination of these regions may be of much assistance in diagnosis.

Diabetes mellitus is slightly less common than pigmentation, being

Diabetes mellitus

found in 78 per cent of the cases. Before the discovery of insulin the appearance of diabetes mellitus was an ominous event, because death usually occurred within twelve months, the diabetes often being of severe type. From a biochemical point of view, however, it does not appear to differ from ordinary diabetes mellitus, and its treatment by insulin and diet is exactly as for this condition (see article DIABETES MELLITUS, Vol. III, p. 651). Some cases, however, appear to have an undue liability to hypoglycaemic shock after the administration of insulin, which has been thought to be due to the concomitant involvement of the liver and pituitary gland. This, however, is not common, and most patients with haemochromatosis react normally to insulin.

Cirrhosis of liver

Hepatic cirrhosis is present in all cases and produces its characteristic clinical symptoms (see LIVER DISEASES). The cirrhosis is nearly always hypertrophic, and in many cases the liver is considerably enlarged, reaching to the umbilicus. An atrophic cirrhosis is rare, occurring in only 7 per cent of the cases. The cirrhosis develops more slowly than in ordinary cases ascribed to alcoholism, and the hepatic enlargement may have been known to exist for some time before the appearance of other symptoms. Ascites is common, but a collateral circulation is rare. Splenic enlargement of moderate extent (one or two finger-breadths) is common. Upper abdominal pain, associated with enlargement of the liver, is the commonest subjective symptom.

*Endocrine symptoms**Loss of hair*

Endocrine symptoms should be looked for in all cases. The characteristic syndrome consists of two sets of symptoms: (i) an alteration of the secondary sexual hair, the hair in the axillae and on the chest being lost and the pubic hair thinned and of a feminine distribution; in addition the hair of the head is usually soft and silky, and the necessity for both hair-cutting and shaving is often much less than normal; one patient who had reached the rank of sergeant-major in the regular army had had only one shave a week, and two, or at the most three, hair-cuts a year; the other clinical symptoms of the disease appeared many years later; (ii) impotence, which is usually a late symptom, the testicles sometimes being small and soft, and sometimes lacking in their characteristic sensation.

*Impotence**Minor symptoms and signs*

Of these four symptoms, forming the tetrad of the disease, hepatic cirrhosis is invariably present, whereas any or all of the remaining three may be absent. The remaining symptoms are not so important. A curious drowsiness and listlessness are present in many cases. Changes in the central nervous system are rare, but Kuipers adduced evidence that the mid-brain might be affected, and it is possible that the apathy may be connected with such changes. X-ray examinations are consistently negative, a somewhat surprising fact in view of the extent of the deposits of iron. The blood-pressure tends to be low (average 111-120/71-80 mm. Hg). There is an increasing volume of evidence that the heart is affected by its load of pigment, leading in time to the clinical signs of myocardial failure in many cases (Murray Lyon). Indeed, even when clinical evidence of heart failure is not present, the

electrocardiogram may indicate myocardial degeneration. The urine, *Urine* apart from the diabetic changes, is normal in most cases, though an examination of the urinary sediment may show intracellular granules of haemosiderin (Rous' test). A history of alcoholism is not found with any special frequency. The Wassermann reaction is usually negative, and the disease is not in any way related to syphilis. The blood does not *Blood* show any characteristic changes. There is not any significant anaemia (average count slightly over 4,000,000 red cells, and 80 per cent haemoglobin), and the red-cell fragility is within normal limits. Purpura has been recorded in a few cases, usually as a terminal phenomenon. Metabolic investigations do not yield any information of clinical value. *Metabolism* The basal metabolic rate is normal. A possible defect in the metabolism of urobilin has been much canvassed, but it does not appear that any changes found are more than could be accounted for by the cirrhosis of the liver.

5.—COURSE AND PROGNOSIS

The disease is inevitably fatal, but the actual cause of death is tending to change. Before the discovery of insulin the great majority of patients died in diabetic coma, which still remains the commonest cause of death. *Causes of death* Unfortunately, the extension in time that is provided for many cases by the appropriate use of insulin only allows the remaining features an opportunity for further development, with the result that there is an increasing tendency for patients to die either from the hepatic cirrhosis or from cardiac failure.

6.—DIAGNOSIS

In a case presenting the whole clinical picture the diagnosis is obvious. Difficulty arises in the absence of one or more of the symptoms, such as diabetes mellitus, or pigmentation. In some of these cases it may be impossible to make a clinical diagnosis, which accounts for the fact that even under conditions of accurate observation the diagnosis in some cases still comes as a surprise at the necropsy. When the possibility of haemochromatosis is suspected, the following procedures are useful: (i) *Examination of patient* a biopsy of the skin; in haemochromatosis with pigmentation granules of haemosiderin are found, especially in the sweat glands; (ii) a Rous' test of the urine (see above); (iii) an examination of the nasal chambers and of the larynx and epiglottis for pigmentation; and (iv) an examination for sexual hypoplasia, which is important in making a differential diagnosis. A history of pigmentation for many years and a long-standing diminished need for shaving and hair-cutting are features of the case-history which may help the decision in a doubtful case.

7.—TREATMENT

There is not any known treatment which affects the whole disease. The treatment of its isolated features, such as the hepatic cirrhosis and the diabetes, lies along the lines appropriate for each condition.

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HAEMOGLOBINURIA

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Reference may also be made to the following titles:

ANAEMIA	BLOOD EXAMINATION
BLACKWATER FEVER	BLOOD TRANSFUSION

1.—DEFINITION

588.] Haemoglobinuria is the name applied to various symptom-complexes characterized by the passage of haemoglobin in the urine.

2.—AETIOLOGY

The mechanisms which result in haemolysis and haemoglobinuria remain obscure, but for clinical purposes the causes can be classified as: (i) chemical substances, such as potassium chlorate, quinine, pyrogallie acid, naphthol, toluylenediamine, carbolic acid, carbon monoxide, arsine, and muscarine; (ii) infective agents, such as those of syphilis, malaria, yellow fever, scarlet fever, enteric fever, and Oroya fever; the *Clostridium welchii* which occurs in the tissues in gas gangrene may also lead to haemoglobinuria; (iii) blood transfusion, owing to faulty matching of the donor's and recipient's blood; (iv) fabism, i.e. idiosyncrasy to the bean *Vicia faba*; (v) pregnancy and the puerperium; (vi) extremes of temperature, such as exposure to cold or burns of the skin; (vii) muscular exertion, resulting in 'exercise haemoglobinuria'; (viii) haemolytic anaemias of the Marchiafava-Micheli or Lederer type; and (ix) paralytic haemoglobinuria, of which the cause is unknown.

3.—PATHOLOGY

Haemoglobin exists in the human body as the pigment of the red blood-corpuscles and also as myohaemoglobin, the colouring matter of muscles. These two forms of haemoglobin can be distinguished spectroscopically. Haemoglobinuria results from an excessive and rapid intravascular lysis of red cells: myohaemoglobinuria is very rare in man, although not uncommon in animals. The causes of intravascular haemolysis and haemoglobinuria will be considered later, but in general it may be stated that probably only 5 to 10 per cent of the haemoglobin liberated from the red cells appears in the urine. In every case of haemoglobinuria there is therefore some degree of anaemia and haemoglobinaemia. In blackwater fever Fairley described the presence in the blood of an unnamed pigment, closely allied to methaemoglobin, for which he suggested the name pseudo-methaemoglobin. The excess of blood pigment in the plasma is usually excreted as bile pigment, without the production of clinical jaundice, although the blood may give an indirect van den Bergh reaction. Clinical jaundice will result if in addition the liver is damaged, as may be the case in severe anaemia owing to anoxaemia.

Source of the haemoglobin

Jaundice

The urine

The urine varies in colour from an almost black, dark brown, or deep burgundy colour to pale red. The pigment present consists of various amounts of haemoglobin, oxyhaemoglobin, or methaemoglobin. Uroerythrin may give the urine a rose-pink colour. The deposit may contain a haemoglobin detritus with haematin or haemosiderin granules. Red cells in various stages of decolorization together with granules and red-cell casts may also be present. In paroxysmal haemoglobinuria albuminuria is present during the attack and may persist for a day or so after the red colour has disappeared from the urine.

4.—CLINICAL PICTURE

A short account of some of the clinical forms of haemoglobinuria will now be given. Blackwater fever, which is associated with malaria, is considered in a separate article (see Vol. II, p. 361). *Blackwater fever*

(1)—Haemoglobinuria due to Chemical Agents

(a) *Quinine Haemoglobinuria*

589.] Terplan and Javert recorded fatal haemoglobinuria due to quinine, which was taken by a woman to terminate a three months' pregnancy. The patient died of uraemia, with a blood urea content of 344 mgm. per 100 c.c. Haemoglobinuric infarcts in the kidneys were found at necropsy. At least eight other cases have been published of fatal haemoglobinuria due to quinine taken in the early stages of pregnancy. *Used as abortifacient*

(b) *Arsine Haemoglobinuria*

Panton, Maitland-Jones, and Riddoch described two cases of arsine haemoglobinuria in men who supervised the mixing of zinc and sulphuric acid in open vessels. Both of the ingredients of the mixture contained arsenic. Dudley observed some men who were admitted to hospital from two submarines with a diagnosis of carbon dioxide or carbon monoxide poisoning. They were found to be suffering from poisoning from arseniuretted hydrogen gas evolved from batteries in the submarines. The metallic portion of the plates contained 0.2 per cent of arsenic, which was the source of the poisoning. The cases were characterized by an onset with headache, nausea, and vomiting; a severe anaemia then developed, with a tendency to leucopenia and a slight degree of icterus; and in one case the urine was dark brown to blood-red owing to the presence of haemoglobin.

(2)—Mismatched Blood Transfusion

590.] When an incompatible blood is used in transfusion, the reaction provoked depends to a certain extent upon the size of the transfusion. As small an amount as 100 c.c. may prove fatal. The immediate reaction consists in a feeling of distress, pains in the loins, headache, shivering, and rise of temperature, followed by a rigor, vomiting, and possibly urticaria (see also BLOOD TRANSFUSION, Vol. II, p. 541). If this reaction does not prove fatal, death may subsequently occur from renal failure with haemoglobinuria. Baker and Dodds showed that the blood urea might reach a level of 803 mgm. per 100 c.c. before death. The donor's red cells are rapidly agglutinated and haemolysed with resulting haemoglobinuria. The haemoglobin is precipitated in the renal tubules as a variety of acid haematin if the reaction of the urine reaches a pH of 6 or lower and the concentration of sodium chloride in the urine is up to 1 per cent. Death, from uraemia, is only likely to occur if there is blockage of the renal tubules. *Symptoms*

(3)—Fabism

591.] In some persons haemoglobinuria results from eating the beans or seeds of the *Vicia faba* or even from inhaling the pollen from its flowers. The disease has been known for centuries and was described by Herodotus and Pythagoras. It is met with now in Sicily, Sardinia, and southern Italy, during the months of April to July, when the beans are in flower, ripening, or in seed.

*Incidence**Actiology*

Preti, describing his observations on this disease, showed that it did not bear any relationship to malaria, syphilis, or to exposure to cold. He considered that it was a manifestation of anaphylaxis, some persons becoming sensitized to the bean or to the pollen of its flowers. It is therefore thought to be allergic rather than toxic in origin.

Clinical features

The disease is characterized by a sudden onset, with languor, stupor, and sometimes nausea, vomiting, and diarrhoea. Anaemia with an initial leucopenia, icterus, and haemoglobinuria rapidly ensue, with enlargement of the liver and spleen, and often there is a high temperature with rigors. A mortality rate of about 8 per cent has been observed in Sardinia.

*Mortality***(4)—Paroxysmal Haemoglobinurias**

592]. The types of haemoglobinuria which occur in paroxysms form a striking clinical picture and are of great interest. They fall into four groups.

*(a) Cold Haemoglobinuria**Association with syphilis*

Gull in 1866 was one of the first to recognize that chill as well as ague could cause haemoglobinuria. In 1879 Murri emphasized the aetiological relation of syphilis to cold haemoglobinuria. In the majority of cases the patient is the subject of congenital syphilis. The disease occurs chiefly in adult males; in 30 per cent of cases there is clinical evidence of syphilis, and in 90 per cent of cases the blood Wassermann reaction is positive.

Clinical features

The attack is provoked by exposure to cold, which may be only trivial. During an attack there is constitutional disturbance, with malaise, headache, nausea, vomiting, aching in the back, legs, or abdomen, pains in the joints, and coldness of the exposed parts of the body. The temperature may rise to 101° F. or higher with a rigor. In some cases there is not any fever. During or directly after the attack the urine becomes dark red or nearly black owing to the presence of haemoglobin and its derivatives. The spleen and liver may be palpable during an attack, and after an attack a slight degree of icterus may be noticed.

Rosenbach's test

Rosenbach showed in 1880 that an attack of haemoglobinuria could be artificially induced in a susceptible subject by immersing the feet in ice-cold water for ten minutes (Rosenbach test).

Donath-Landsteiner reaction

A further advance in our knowledge of the disease was made in 1904 by Donath and Landsteiner, who demonstrated that the serum or plasma of a patient contained a lysin which united with the red cells

only when the blood was cooled. This autohaemolysin acts as an amboceptor; on warming the blood complement unites with the red-cell-amboceptor complex, and lysis of the red cells ensues. The phenomenon can be demonstrated outside the body in a test-tube and constitutes the Donath-Landsteiner reaction. The presence of carbon dioxide may also be an additional factor in the mechanism of haemolysis. It is not known why an autohaemolysin is present in the blood of some patients suffering from syphilis and absent in others. In some cases of cold haemoglobinuria intravascular clotting occurs, with gangrene of the fingers, toes, or tip of the nose. Mackenzie in 1929 gave an interesting review of the subject.

(b) *Exercise Haemoglobinuria*

Physical exertion or standing in a position of lordosis will provoke haemoglobinuria in some persons. It was described as occurring chiefly in soldiers by Porges and Strisower in 1913. Exercise haemoglobinuria appears to be allied to postural albuminuria, occurring almost entirely in young males between the ages of ten and twenty years. There are not any constitutional symptoms, and the patient usually grows out of it. The condition is not related to chilling, the Donath-Landsteiner reaction is negative, and the patients are not syphilitic. There are not usually any blood changes, and it has been suggested that the haemolysis occurs in the renal vessels.

(c) *Haemolytic Anaemia with Haemoglobinuria*

(i) The Marchiafava-Micheli type of haemolytic leucopenic anaemia with recurrent or nocturnal haemoglobinuria (and haemosiderinuria). A peculiar feature of this recurrent variety of haemoglobinuria is that it tends to occur at night. In 1928 Marchiafava described a case of haemolytic anaemia with perpetual haemosiderinuria.

Marchiafava-Micheli anaemia

An aviator, aged 32, had been involved in several flying accidents and had suffered from anaemia with leucopenia for three years. After a blood transfusion he first passed coffee-coloured urine. The red cells did not show increased fragility, the spleen was not enlarged, and there was a fleeting and variable slight icterus. In the urinary deposit haemosiderin was often found, methaemoglobin being also present on two occasions.

Clinical picture

The cases of haemolytic leucopenic anaemia were originally confused with haemolytic icterus but are distinguished from haemolytic icterus by the haemoglobinuria, the normal or only slightly increased fragility of the red cells, the high reticulocyte count, and the post-mortem appearances of the spleen. In a typical case there is a slowly progressive anaemia and, later, paroxysms of haemoglobinuria, which usually develop or are most marked during the night.

Diagnosis from haemolytic icterus

In short attacks the urine passed during the night is richest in haemoglobin, that voided during the day containing very little haemoglobin. In severe attacks the night urine is darker than the day urine and, as

The urine

Incidence

the attack passes off, only the night urine is dark. Although Marchiafava drew attention to the presence of haemosiderin in the urine sediment, it may only occur intermittently, as described by Micheli; Rosenthal also agreed that its presence is not constant. In some cases the haemoglobinuria is noticed before the anaemia is detected. Witts (1932) recorded a case conforming to this type, bringing the total published up to 27, 17 males and 10 females. Rosenthal published an interesting review entitled 'A new form of paroxysmal haemoglobinuria', in which he described a case:

Clinical picture

A male, aged 18, without any previous exposure to cold or violent muscular exertion, was seized with shivering, loin pains, and fever and passed coffee-black urine. Recurrences occurred, of various degrees of severity, for thirty years, when the clinical picture altered, in as much as the patient remained permanently ill between the attacks, owing to weakness, anaemia, and a periodically increasing low-grade jaundice. He was at different times suspected to be suffering from Banti's disease, pernicious anaemia, and haemolytic icterus. Three years later both liver and spleen were enlarged. The blood then showed a haemoglobin content of 35 per cent, red cells 1.5 millions, colour index 1, reticulocytes 12 to 15 per cent, white cells 3,500, lymphocytes 50 per cent, neutrophils 40 per cent, monocytes 10 per cent; the fragility of the red cells was normal. The Donath-Landsteiner reaction was always negative, and cooling of the limbs did not provoke any reaction. The patient died fourteen hours after splenectomy.

I recently observed a further case (unpublished) under the care of Dr. G. E. S. Ward in the Middlesex Hospital, London:

A woman, aged 24, suffered from severe anaemia at the age of 13, which was diagnosed as 'chlorosis', and at the same time also complained of menorrhagia. Eleven years later (May, 1936) she suffered from pains in the epigastrium and back, with jaundice, and the urine was dark, especially the nocturnal specimens. In July, 1936, the blood count showed red cells 2.6 millions, haemoglobin 55 per cent, reticulocytes 19 per cent, leucocytes 3,000. The patient subsequently had attacks of haemoglobinuria, chiefly nocturnal, with jaundice. During one attack the urine contained 2.7 grams of haemoglobin by night and 1.1 grams by day. Her condition deteriorated until a severe syncopal attack occurred with a haemoglobin of 45 per cent. This was relieved by a drip blood transfusion, the haemoglobin level being raised to 90 per cent.

These cases illustrate the typical features of the disease and clearly differentiate it from haemolytic icterus, in the most severe forms of which haemoglobinuria does not occur, and emphasize the fact that splenectomy must not be performed in this type of haemoglobinuria.

Lederer's anaemia

(ii) Lederer's anaemia. This is an acute haemolytic anaemia of unknown origin which most often affects children but may occur in adults, especially during pregnancy. O'Donoghue and Witts described the occurrence of haemoglobinuria in severe cases. There is leucocytosis of 20,000 to 40,000 in this disease in contrast to the leucopenia which characterizes the haemolytic anaemia with nocturnal haemoglobinuria.

(d) *Paralytic Haemoglobinuria (Paroxysmal Myoglobinuria)*

This is a rare disease, only three cases having been recorded. It is characterized by muscular atrophy, with recurrent attacks of haemoglobinuria. The pigment in the urine is myohaemoglobin derived from the muscles. At necropsy the affected muscles are white—like ‘fish flesh’.

Meyer-Betz recorded the first case in 1911 and pointed out the resemblance to the condition well known in horses, in which black urine is passed. This symptom is likely to occur in an affected animal when, after a few days’ rest, with good food, it is taken out to work. It develops muscular weakness or paralysis of the hind limbs and voids urine darkened by myohaemoglobin. Death may rapidly ensue.

Meyer-Betz’s patient was a boy, aged 13, who developed extraordinary muscle weakness with sudden attacks of paroxysmal haemoglobinuria. The condition improved slowly and gradually after the cessation of the attacks of haemoglobinuria.

Günther proposed the names myoglobinaemia and myoglobinuria for the form of haemoglobinuria of this class; his patient had myositis, with almost complete loss of the red colour of the affected muscles, and an output of a myohaemoglobin derivative in the urine. Paul’s patient died within fourteen days of the onset, having suffered severe muscular pains, with great loss of strength and finally paralysis; the necropsy showed extensive waxy degeneration of the muscles and blocking of the renal tubules with masses of haemoglobin.

5.—DIAGNOSIS

593.] The diagnosis in any suspected case of haemoglobinuria depends on a chemical and spectroscopic examination of the urine. The clinical basis of the differential diagnosis of the type of haemoglobinuria has been considered in the preceding sections. The chief confusion has arisen in the recognition of the nature of the haemolytic anaemic type of haemoglobinuria. Thus Chauffard and Troisier, and Giffin believed that their cases should be described as haemolytic icterus with haemoglobinuria. Panton, Maitland-Jones, and Riddoch were impressed with the resemblance of their cases to pernicious anaemia. The haemolytic anaemic type of recurrent haemoglobinuria has its peculiar features as detailed above, and although the fragility of the red cells is slightly increased in some cases this phenomenon is not as marked as in haemolytic icterus. The high reticulocyte count and absence of response to liver treatment distinguish it from pernicious anaemia.

6.—TREATMENT

The treatment in any case of haemoglobinuria must vary with the cause, if it be known, or with the type of disease. In some cases, as in that

form due to mismatched blood transfusions, treatment is preventive, adequate care being taken to ensure correct grouping of donor and recipient (see BLOOD TRANSFUSION, Vol. II, p. 542). The administration of alkalis by mouth to the recipient is also a wise precaution. In the group of cases due to chemical substances the causal agent must be removed. In the infective group treatment is directed to the disease of which the haemoglobinuria is a symptom. Cold haemoglobinuria can usually be cured by appropriate antisyphilitic treatment. One case of exercise haemoglobinuria has been recorded by Panton, Maitland-Jones, and Riddoch which was cured by four injections of horse serum. No special treatment is available for paralytic haemoglobinuria. The disease may remit spontaneously or prove rapidly fatal. The outlook in the haemolytic anaemic type of haemoglobinuria is very grave; splenectomy should never be advised, and the most hopeful line of treatment lies in repeated small transfusions of about 500 c.c. of compatible blood. Large transfusions are liable to provoke further haemoglobinuric crises.

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HAEMOPHILIA

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Reference may also be made to the following titles:

BLOOD EXAMINATION HAEMORRHAGIC DISEASES
HEREDITY AND CONSTITUTION

1.—DEFINITION

594.] An hereditary disease affecting males and characterized by a delay in the coagulation time of the blood and a tendency to recurrent haemorrhages.

2.—AETIOLOGY

Haemophilia is generally regarded as an hereditary character, sex-linked and recessive. It appears only in males and is transmitted characteristically through the females who are free from it (see Fig. 13); according to Birch it may be transmitted occasionally through the male. True haemophilia may occur in a female only if she is the daughter of a haemophilic male and a haemophilia-transmitting female. Such an occurrence is obviously extremely rare. An authentic case was recently reported (Handley and Nussbrecher). Many of the cases recorded as

haemophilia in females are examples of the rare diseases known as constitutional thrombopathy (von Willebrand) and hereditary haemo-

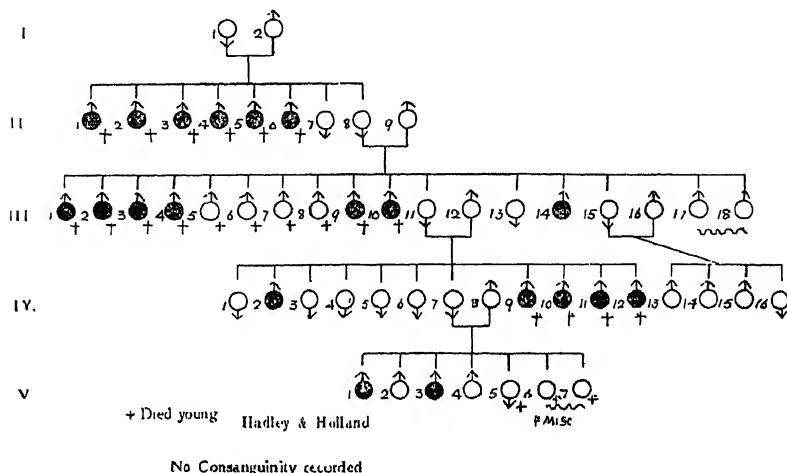


FIG. 13.—Haemophilia. Twenty cases in 5 generations
(*Eugenics Laboratories Memoirs*)

philic thrombasthenia (Glanzmann). Members of the Latin races are rarely affected. Social conditions do not play any known aetiological part.

3.—PATHOLOGY

Changes in the blood

The essential pathological feature of the disease is the markedly delayed coagulation time of the blood, due to defective activation of prothrombin to thrombin. The blood-platelets are normal in quantity but are unduly stable, with the result that the liberation of thrombokinase is delayed. The blood may remain fluid in a test-tube for 40 minutes or longer, compared to a normal clotting time of 5 to 7 minutes. When haemophilic blood coagulates, the clot usually retracts properly. The bleeding time, as determined from a single stab with a needle, is not increased (see Vol. II, p. 483). Structural changes in the walls of blood-vessels have been claimed to be present, but this explanation of the haemorrhagic tendency is not generally accepted. Apart from hypochromic anaemia secondary to haemorrhage, significant changes in the red-cell picture are not found.

4.—CLINICAL PICTURE

The clinical manifestations of haemophilia are essentially those of haemorrhage. The tendency to bleed appears in the majority of patients by the second or third year of life but is rarely present at birth, excessive

bleeding from the umbilical cord being seldom noticed. Some injury probably initiates the haemorrhage, but the trauma may be so slight as to escape attention, and as a result a spontaneous origin is accepted. A slight knock or abrasion or an excessive muscular contraction may be sufficient to start the bleeding, which is characterized more by its persistence than by its severity. The haemorrhagic manifestations may be classified as (i) external, (ii) interstitial, and (iii) articular.

(i) *External haemorrhage*

Bleeding from the nose is the commonest and most fatal form of external haemorrhage. The sites next in order of frequency are the gums, gastro-intestinal tract, urethra, and lungs. External traumatic haemorrhages are especially dangerous. Death has resulted from bleeding after the extraction of a tooth or after circumcision. A cut from a razor in shaving may ooze for hours despite the formation of a large loose clot. Small punctures do not bleed freely: hence a blood examination can be safely carried out. The blood should be removed from the finger rather than the ear. Vein puncture is safe, provided that a small-bore needle is used.

*Blood
examination*

(ii) *Interstitial haemorrhage*

Petechial haemorrhages are extremely rare, a point of importance in the differential diagnosis of haemophilia from thrombocytopenic purpura and scurvy. Large subcutaneous or intramuscular haemorrhages are common and lead to great pain and disability. Effusion of blood into the walls of the stomach or intestine may produce symptoms and signs closely simulating those of acute inflammatory disease in the abdomen, e.g. appendicitis. The spleen is never enlarged. Haemorrhages into the serous sacs or meninges are rare.

(iii) *Articular haemorrhages*

Bleeding into the synovial cavities of joints is common, the elbows and knees being most often affected. The haemorrhage is recognized by the sudden onset of pain and swelling in the joint, which is hot, tender, and red. Fluctuation may be elicited and the temperature is raised. A mistaken diagnosis of rheumatism may be made. Although in some cases function is rapidly and completely restored, in many it is incomplete, the degree of functional efficiency varying from a slight loss of movement and some stiffness to complete ankylosis and contractures. Articular haemorrhages are especially common in childhood.

*Restoration
of function*

5.—COURSE AND PROGNOSIS

The prognosis in childhood is grave. Statistical analyses show that prior to modern methods of prophylactic treatment nearly 90 per cent of haemophilic children died before puberty. The tendency to bleed

diminishes as age advances. Adolescence brings a measure of respite, and the chances of survival are excellent if adult life is attained. Nevertheless the haemorrhagic tendency is present, although latent, in adult life, and injuries and operations should be avoided as far as possible at any age. The active phase of the disease is seldom present in a severe degree continuously. Changes occur in the coagulation time of the blood for reasons unknown, and in the intervals between bleedings patients may remain well for months or years. Of particular prognostic importance in relation to economic efficiency is the prevention of permanent changes in the joints.

6.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

*Coagulation
time*

The sex and family incidence and a history of bleeding and bruising since childhood are points of great importance. Failure to obtain a family history of bleeding sometimes occurs and can probably be explained by the wide spread diffusion of the disease in a recessive form with the passage of centuries rather than by a spontaneous origin. In the active stage of the disease a prolongation of the coagulation time is invariably present, and the diagnosis is not justified without this finding. This criterion, however, may be absent between the attacks of bleeding. The normal platelet count (see Vol. II, p. 481), bleeding time, and capillary resistance test (see p. 145) differentiate the condition from thrombocytopenic purpura. Hereditary and familial diseases, occurring in males and females and characterized by a tendency to bleed, have been described (Glanzmann; von Willebrand). The normal coagulation time and prolonged bleeding time of the blood in these extremely rare hereditary diseases serve to distinguish them from haemophilia.

7.—TREATMENT

The relative rarity of the disease and the spontaneous fluctuations in the tendency to bleeding make the merits of any therapeutic measures difficult to assess.

(1)—Prophylaxis

Eugenics

As the disease is hereditary, an effort should be made to control its spread by eugenic measures. Females born of haemophilic stock should be told that, for the sake of posterity, child-bearing must not be undertaken. There is apparently no record of the transmission of haemophilia to the male grandchildren of a haemophilic male and a healthy female.

*Avoidance
of trauma*

Prophylaxis of attacks of bleeding consists in regulating the patient's mode of life and activities so that the chances of trauma are reduced to a minimum. The dangers of trivial injury should be explained to the

patient or his parents. Should operation be necessary, special prophylactic measures should be taken (see below).

(2)—Treatment of Attack

Energetic measures should be immediately taken to stop the haemorrhage, because the dilution of the blood which occurs, if anaemia is allowed to develop, lowers the concentration of the blood-clotting elements. The use of haemostatic sera and of drugs, such as calcium compounds, adrenaline, ergot, parathyroid extract, and oestrogenic substances, cannot be recommended, as there is little evidence that they are of value in altering the course of the disease. Their use may even be a danger, as it involves delay in the use of measures of proved value. If the site of haemorrhage is not accessible, or if the bleeding is severe, transfusion of one pint of citrated blood should be given (see Vol. II, p. 537). This will control the haemorrhagic tendency for several days, and the transfusion can then be repeated if necessary. In less severe cases the intramuscular injection of 10 to 30 c.c. of whole blood may suffice. In children the intraperitoneal transfusion of blood has been shown to be a satisfactory pre-operative measure.

General treatment of haemorrhage

Drugs to be avoided

Transfusion

Injection

Local treatment of haemorrhage

Viper venom

Danger of sutures

Treatment of haematomas and haemarthroses

If bleeding takes place from an accessible situation, e.g. nose, tooth socket, or a cut, the bleeding area should be gently cleaned and useless clots removed. A dressing soaked in normal fresh whole blood or serum should then be applied and kept firmly in position. Special bandages, packs, plates, or splints may be required to maintain an effective pressure and to reduce movement to a minimum. The claims of Macfarlane regarding the value of the venom of Russell's viper as a local haemostatic have now been confirmed. The dressings are soaked in a 1 in 10,000 dilution of the venom and applied in the manner described above. By this means bleeding is usually immediately controlled and damage of local tissue does not result. The venom from the Moccasin snake (*Ancistrodon piscivorus*) in a dilution of 1 in 3,000 has been injected subcutaneously in doses of 0.4 to 1 c.c. to control bleeding. Pressure should not be maintained for more than a few hours, owing to the devitalization of tissues which it produces. If bleeding continues a fresh dressing soaked in blood, or, better still, viper venom dilution, should be applied. Sutures are not indicated except for arterial bleeding, as they frequently 'cut out' and thus increase the bleeding. Cauterization is worse than useless.

Haematomas and swollen joints should not be opened, and orthopaedic treatment should be undertaken by the use of splints and cages to put the parts at rest until pain and swelling disappear. After the acute symptoms have subsided, heat, gentle massage, and passive movements are indicated.

(3)—Treatment between Attacks

The suggestion of Vines, that the thrombogenic functions of the somatic cells may be stimulated by the induction of a modified form of

*Induction
of protein
hyper-
sensitivity*

anaphylactic shock, received the enthusiastic support of Mills, who claimed that, so long as a state of hypersensitivity was maintained, the coagulation time of the blood was kept low. Mills recommended the following technique:

*Mills's
method*

An intradermal injection of sheep or hen serum is first given to ascertain whether or not the patient is already sensitive. If not, 3 or 4 c.c. are injected intramuscularly, and fourteen days later another intradermal injection is given. An urticarial wheal should now appear, indicating that the patient is sensitized. If the coagulation time has not now shortened sufficiently, further intradermal injections should be given at weekly intervals, in different skin areas. This does not tend to reduce the general sensitivity. Thereafter the coagulation time should be the guide as to the frequency of the intradermal injections. Sensitivity usually lasts for at least a year, and at the end of that time it should be renewed by a further intramuscular injection of the same or a different protein.

Particular care should be taken to avoid injection of the serum subcutaneously while an intradermal injection is being given, as in this way a generalized reaction may precipitate the patient into a haemorrhagic stage.

*Modification
of Mills's
method*

Eley and Clifford (1931) treated eight haemophilic children by a modification of the above method, using intradermal injections of horse serum at fortnightly intervals. They confirmed Mills's finding that a rapid and marked reduction in the coagulation time of the capillary blood could be obtained and maintained, but the coagulation time of the venous blood was unaltered. The treatment was definitely beneficial in the prevention or control of bleeding from superficial injuries, but was of little value when large vessels were injured or for the prevention of effusions into joints or of haematomas.

*Use of human
placental
extracts*

A recent study by Eley and his co-workers (1936) has been made into the value of the oral and intramuscular administration of extracts made from human placental tissues: fifteen haemophilic children were treated, and the data presented show clearly that a marked reduction of both the capillary and venous coagulation times was obtained. The clinical effects appear to be superior to those produced by protein hypersensitivity.

It would appear that in selected cases some beneficial results may be expected from either of the forms of treatment detailed above. An extended trial under control conditions is obviously desirable in this country.

*General
measures
Diet and
exercise*

The general health should be maintained at as high a level as possible by the administration of a well balanced diet and by regulated exercise in the fresh air and sunshine. Since there is some evidence to support the view that the coagulability of the blood can be influenced favourably by the absorption of protein from the intestine, a high-protein diet has been recommended as a prophylactic measure. In addition to a moderate intake of protein at each of the three main meals, Mills

recommends a glass of milk or an egg-nog between meals and once during the night. If anaemia is present, iron should be prescribed in adequate doses and treatment continued until a normal haemoglobin figure is attained.

Timperley, Naish, and Clark have recently reported a new method for the treatment of haemophilia, which is claimed to produce excellent results in reducing the clotting time of the blood and controlling haemorrhage. Egg-white, intimately mixed with potassium bromide, is incubated at 37° C. for three days, dilute alcohol is added, the mixture filtered, and the active material precipitated by means of acetone. The purified mixture is injected at intervals into the patient's vein. Sufficient time has not elapsed for independent observers to have confirmed this work, but the case records submitted by the authors are so striking as to warrant further investigation. *Use of egg-white*

It is well recognized that sepsis can play an important part in lowering the general health, in retarding the response of the haematopoietic tissues to haemorrhage, in damaging the endothelial lining of blood-vessels, and in initiating arthritis or influencing it unfavourably when it has occurred. Accordingly, despite the risks involved, obvious septic foci must be eradicated. The operation should be postponed, if possible, until the disease is in a quiescent state. Transfusion of blood before and after the operation, as well as other measures mentioned above, may be necessary for the control of haemorrhage. *Removal of septic foci*

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HAEMOPTYSIS

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Reference may also be made to the following titles:

EPISTAXIS	HEART DISEASES
HAEMATEMESIS	LUNG DISEASES

1.—DEFINITION

595.] Haemoptysis (*αἷμα*, blood; *πτύσις*, spitting) connotes the expectoration of blood from the respiratory tract—the larynx, trachea, bronchi, and lungs—or broncho-pulmonary haemorrhage. Like haematemesis and haematuria, it is a manifestation of a number of different causes. It must be distinguished from false or spurious haemoptysis—namely, bleeding from the mouth, nasopharynx, and the parts above the larynx.

*Spurious
haemoptysis*

Spurious haemoptysis may be due to any of the following causes: (1) Inflammations and ulcerations of the mucous membrane of the mouth—e.g. of the gums, tongue, and tonsils. These conditions include ulcerative stomatitis with oral sepsis, grave haemorrhagic states, acute leukaemia, scurvy, mercurialism, and ulcers due to tuberculosis and trauma. (2) Epistaxis from the posterior nares, the blood trickling down towards the larynx and exciting cough; among the causes of epistaxis attention may be directed to high blood-pressure, hepatic cirrhosis, diseases of the blood-forming organs, multiple telangiectases,

polypi, and malignant tumours of the accessory nasal sinuses (see EPISTAXIS, Vol. V, p. 142). (3) Pharyngeal ulceration, due to factors such as those mentioned above. (4) Hysteria and malingering, in which there may be obvious bleeding punctures in the mouth or nasopharynx, or in which microscopical, serological, or other examination of the 'blood' may establish its animal or other extrinsic nature.

In spurious haemoptysis, which is probably too often, optimistically, diagnosed, the blood, being mixed with saliva, is usually more watery and paler than in true haemoptysis.

*Differential
diagnosis
pulmonary
haemoptysis*

2.—AETIOLOGY

Almost all the morbid lesions of the lungs may cause bleeding, but their importance in this respect naturally varies widely. Some causes which are relatively of more interest than importance in practice may first be dismissed with a brief reference. In acute lobar pneumonia the sputum is usually 'rusty' or 'prune-juice' in appearance, but in rare instances the onset may be marked by the expectoration of bright blood, and may arouse a suspicion of tuberculosis. After the expulsion of casts in plastic bronchitis there may be bleeding. Among common chronic pulmonary lesions emphysema, which is often associated with arteriosclerosis, may be the only obvious cause of slight bleeding. In very rare instances non-tuberculous haemoptysis has been associated with emphysema and chronic interstitial nephritis (Hawkins).

Various forms of parasitic bronchitis, chiefly in tropical countries, may cause haemorrhage, for example spirochaetosis icterohaemorrhagica, the late stages of histoplasmosis (see p. 521), and the endemic haemoptysis in the Far East due to distomiasis (*Paragonimus westermani*).

*Parasitic
haemoptysis*

In general haemorrhagic states, such as the haemorrhagic or malignant exanthemata and acute leukaemia, blood may appear in the mouth. Hereditary haemoptysis in seven members in three generations of a Jewish family, without any evidence of tuberculosis, was recorded by Libman and Ottenberg, who compared it to the hereditary and familial forms of haematuria described by Guthrie and by Attlee. Haemoptysis as a form of vicarious menstruation was formerly recognized, but modern opinion is incredulous and inclined to regard the amenorrhoea and haemoptysis as both due to pulmonary tuberculosis, the haemoptysis being rather more likely to occur during the premenstrual temperature rise than at other times.

*Hereditary
haemoptysis*

The most important causes of pulmonary haemorrhage are naturally those in which blood-vessels are most involved, namely, pulmonary tuberculosis, chronic venous engorgement of the lungs in mitral disease, especially mitral stenosis, and the fortunately much less frequent accident of ulceration of an aortic aneurysm into the trachea, bronchi, or even the substance of the lung. Osler and McCrae recognized this by giving a general account of haemoptysis as a symptom under the

*Involvement
of pulmonary
blood-vessels*

Two most frequent causes

heading of circulatory disturbances in the lungs. The two most frequent causes are pulmonary tuberculosis, in which it has been estimated to occur in half the cases, and mitral disease. These two causes are very seldom active in the same case, and it has been thought that the moist condition of the lungs in mitral disease inhibits the development of pulmonary tuberculosis; nevertheless, the association of the two conditions, though uncommon, is not as rare as was formerly believed.

Haemoptysis in early pulmonary tuberculosis

In pulmonary tuberculosis haemoptysis may occur early or late in the course of the disease. It may be the first symptom when the patient feels in good health, and in such circumstances is usually slight, the sputum being streaked with bright blood; but a brisk initial haemoptysis amounting to several ounces is not uncommon. Slight haemoptysis occurring early in the disease has been ascribed to patches of congestion in the bronchioles or lungs, or to ulceration of small branches not only of the pulmonary but also of the bronchial vessels in an area of softening. More considerable haemoptysis in apparent health may be due to latent cavitation in the lung and erosion of a vein or of a small aneurysm on a branch of the pulmonary artery either traversing the cavity or exposed in its walls.

In later pulmonary tuberculosis

Later, in the course of chronic pulmonary tuberculosis with fibrosis and cavitation, haemoptysis of a profuse character is due to erosion of an aneurysm of a branch of the pulmonary artery in the wall of a cavity. The blood may be only partially expectorated, and, if a large quantity passes into the bronchus of the other lung, sudden suffocative death may occur with little or no expectoration of blood. The disease may be spread by aspiration of blood and tubercle-laden material from the cavity into the bronchi of the lower lobe of the same or the opposite lung (tuberculous broncho-pneumonia). After the haemoptysis, in addition to signs of old disease there may be moist sounds due to blood in the small bronchi.

The occurrence of haemoptysis long, sometimes years, after the cessation of symptoms in pulmonary tuberculosis usually indicates a return of activity; but not necessarily, for in some cases the temperature, the pulse-rate, and the blood sedimentation rate are all normal, and the patient remains well.

Bronchiectasis

In bronchiectasis the sputum may be tinged or streaked with blood or there may be a large haemoptysis; the bleeding may occur in the dry form with latency of symptoms and few physical signs, and recur between intervals of good health. Syphilitic disease of the lung may be accompanied by haemoptysis, but this is rare as compared with the incidence in bronchiectasis.

Syphilis of lung

Growths of bronchi and lungs

Haemoptysis, usually small in amount and compared in appearance to red currant jelly, may occur in primary carcinoma of the bronchi, a condition now more often recognized than in the past and responsible for many malignant tumours formerly regarded as primary in the lung or mediastinum. Among 139 cases of primary carcinoma of the lung haemoptysis was recorded in 36 per cent; but in the cases with sputum

it occurred in 70 per cent (S. L. Simpson). Very occasionally, large and fatal haemorrhage occurs in such cases. Blood-stained sputum may be associated with malignant tumours in the mediastinum. Non-malignant tumours in the chest, such as dermoid and hydatid cysts, may cause haemoptysis.

The symptom sometimes occurs in pulmonary abscess, not in early cases, but when a chronic abscess cavity has formed. At this stage there is often an associated secondary bronchiectasis, which may at times be responsible for the bleeding. *Pulmonary abscess*

Other rare causes are gangrene of the lung, rupture of an empyema into a bronchus, and an abscess of the liver which has perforated the diaphragm and the lung. Bullet or other penetrating wounds of the chest and injuries of the lung with or without fracture of the ribs may be responsible, and blood-stained sputum has been recorded in the rare condition of spontaneous haemothorax. *Other pulmonary causes*

Disease, especially stenosis, of the mitral valve with chronic venous engorgement of the lungs comes next in frequency to pulmonary tuberculosis as responsible for haemoptysis. The bleeding may be due to rupture of capillaries or small vessels into the air alveoli; and it is noteworthy in this connexion that the pulmonary vessels may show arteriosclerotic changes in mitral disease. The extravasated blood forms the solid purple masses called 'pulmonary apoplexies' by Laennec. Local pleurisy over them often follows and may lead to a considerable effusion which accounts for increasing dyspnoea. Emboli from a dilated right auricle or from the abdominal or other veins may cause a haemorrhagic infarct in the lung resembling a pulmonary apoplexy. The presence of congestive heart failure in mitral stenosis favours the occurrence of such pulmonary infarction; in 52 cases of mitral stenosis examined after death there were 23 with congestive heart failure, and of these 14, or 61 per cent, showed pulmonary infarction; whereas among the 29 cases without congestive heart failure 2 only, or 7 per cent, showed infarction (Levine and White). Primary thrombosis of branches of the pulmonary artery may have a similar effect, though with a slower onset. At necropsy it may be difficult to decide the relative ages of a clot in a branch of the pulmonary artery and of a pulmonary apoplexy or infarct in the area supplied by that vessel. *Mitral disease*
Pulmonary apoplexy

An aneurysm of the transverse part of the aortic arch, or of the descending part near the attachment of the ductus arteriosus, may press on and cause ulceration of the walls of the trachea or of the left bronchus. A large aortic aneurysm may excavate the lung and 'weep' into it. Ulceration into the trachea or bronchus may cause copious and suddenly fatal bleeding; but sometimes there is leakage due to percolation of blood between the laminated fibrin occupying an aneurysmal sac, and this may go on for a long time. An aneurysm pressing on the left bronchus is often quite small, but is prone by pressure on the left recurrent laryngeal nerve to cause abductor paralysis, a suggestive sign. *Aortic aneurysm*

3.—CLINICAL PICTURE

Onset

The onset of haemoptysis, usually sudden, is ushered in by a tickle in the throat and coughing; a gush of fluid with a salt taste may surprise the patient and when its colour is obvious may seriously alarm him. In early pulmonary tuberculosis, the blood is usually bright red, suggesting that it comes from the pulmonary capillaries or venules; in the more advanced cases with profuse haemorrhage, the blood may come from branches of the pulmonary arteries and is then much darker in colour. The haemorrhage occurs at least as frequently in the night as in the day, and the amount, though usually small, may be as much as several ounces to a pint. As a rule haemorrhage in pulmonary tuberculosis continues intermittently for some days, the patient bringing up blood, often in clots or mixed with sputum, in progressively smaller amounts and at increasing intervals. In some cases the haemorrhage is immediately fatal. The general symptoms are also variable, but restlessness, extreme weakness and pallor, syncope, and a rapid and weak pulse are common.

Diagnosis of site of haemorrhage

Usually it is possible to establish clinically the side from which the blood is coming. In those cases in which haemoptysis is the first symptom of pulmonary tuberculosis, radiography, which may conveniently be carried out by means of a portable X-ray apparatus, usually shows a homogeneous shadow in one lung, in most cases in the subclavicular region. Auscultation may provide the necessary information; thus when blood has been aspirated into both bases there tends to be considerably more on the affected side. The râles caused by aspirated blood are fine and bubbling; they are quite characteristic and should not be mistaken for tuberculous râles. The patient's own sensations may be a useful guide; he usually feels a tickle or fluttering on the side from which the blood is coming.

Other clinical features of haemoptysis are mentioned above in the section on aetiology.

4.—PROGNOSIS

The prognosis depends chiefly on that of the underlying cause; thus it is bad in malignant disease of the lung and in aortic aneurysm, and should be good in pulmonary tuberculosis if the diagnosis is made early and adequate treatment undertaken. The immediate prognosis is generally favourable as regards survival directly from the attack, except in aortic aneurysm and some cases of pulmonary tuberculosis at a late stage.

5.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

Early diagnosis, with the help of radiology and bacteriology, is of the greatest importance, and the diagnosis of spurious haemoptysis (see p. 130) should be the very last resort, after the greatest care has been taken to exclude by far the commonest cause, pulmonary tuberculosis,

in which early treatment is so essential to obtain a cure. It should be taken as axiomatic that haemoptysis *must* suggest pulmonary tuberculosis until another cause has been found.

In practice the differential diagnosis of true from spurious haemoptysis, and of haemoptysis from haematemesis, seldom offers much difficulty. Haemoptysis is accompanied by cough, and the bright blood is usually mixed with sputum, which for some days after is blood-stained. The blood is alkaline and frothy, and in cases of pulmonary tuberculosis may be found to contain tubercle bacilli. There may be a history of pleurisy with effusion, 'bronchitis', or some pulmonary or cardiac disease. The oral evacuation of blood in the absence of previous illness is more likely to be haemoptysis than haematemesis. Sometimes the patient's account of what happened may suggest haematemesis, although it was really haemoptysis; thus, if the haemoptysis occurs at night, the sleeping or drowsy patient may swallow the blood almost unconsciously, and this may be subsequently vomited and also give rise to melaena. In haematemesis the blood is usually dark, acid in reaction, and often clotted; it may contain particles of food. Though a large amount may be brought up, it does not continue to stain sputum when there is any. It is vomited up, but some of it may, when passing the glottis, irritate the larynx and set up coughing, and so confuse the diagnosis when this is based on the patient's account. Haematemesis is often preceded by symptoms of dyspepsia, and shortly before its occurrence there may be faintness from the extravasation of a large quantity of blood into the stomach. As a result of the distension the stomach is stimulated to drive the blood both into the oesophagus and the duodenum. Hence melaena is a feature of haematemesis, and does not occur in haemoptysis unless some of the blood has been swallowed.

*Differential
diagnosis*

*From
haematemesis*

*Between
mitral and
pulmonary
disease*

The diagnosis between mitral disease and a primary disease of the lung, especially tuberculosis, as the cause of haemoptysis, depends on the history and on a complete physical examination when this can be safely carried out. The history of rheumatic disease and the physical signs of mitral stenosis should exclude tuberculosis, even if there are moist or other sounds in the lungs. Such sounds may be due to the presence of blood, to oedema, or a 'pulmonary apoplexy', for pulmonary tuberculosis is rarely superimposed on existing mitral stenosis. The converse, namely, the development of mitral disease in the subject of latent or obsolete pulmonary tuberculosis, may occur, but such a problem seldom arises.

Embolism of a large branch of the pulmonary artery, which, if not at once fatal, may cause slight haemoptysis, is so dramatic in its sudden onset with pain and dyspnoea, imitating indeed the onset of pneumothorax, that the diagnosis should not be difficult.

*Embolism of
pulmonary
artery*

In cases in which a cause for the haemoptysis cannot be found bronchoscopy may help to establish the diagnosis, but this should be delayed until the patient has recovered sufficiently from the loss of blood (see Vol. V, p. 12).

*Use of
bronchoscopy*

6.—TREATMENT

- Prophylaxis* Prevention largely depends on the nature and treatment of the responsible causes, for example pulmonary tuberculosis, cardiac rheumatism, and aortic aneurysm.
- Treatment of the attack* The predominant principle should be complete rest for body and mind; physical examination, except auscultation of the front of the chest or radiography by means of a portable X-ray apparatus, neither of which need disturb the patient, must be postponed until the sputum is no longer tinged with blood. The patient is naturally alarmed at the discovery that he is bringing up blood, and should therefore be reassured as to its significance. Help may be obtained from sedatives: if there is very little bleeding, bromide mixtures containing 15 grains of potassium or sodium bromide, three times a day, may be tried; but in moderate or severe haemoptysis, especially when the patient is agitated, morphine sulphate $\frac{1}{4}$ grain should be given immediately. It is valuable because it serves not only to allay the patient's anxiety but to reduce coughing and so to favour the formation of a coagulum over the bleeding spot. The cough reflex, however, should not be depressed for longer than necessary, for once the haemoptysis has stopped it is essential that aspirated blood should be cleared from the bases. Retention of blood and sputum may lead to broncho-pneumonic infection of previously healthy areas of the lung. Riviere (1928) favoured delay in giving narcotics in large haemoptyses, and for routine use preferred codeine, heroin, or dionin to morphine; his views however are not widely accepted. It is undesirable to combine morphine, given to combat panic, with a mercurial purge, because the colon may then suffer from the delay in the expulsion of the mercury.
- Other drugs* Treatment by drugs, though many have been employed, is disappointing; those acting as vasodilators or vasoconstrictors on the general or pulmonary circulations, such as adrenaline, pituitary (posterior lobe) extract, ergot, and lead, should be avoided. Divergent opinions have been expressed about inhalation of amyl nitrite, but, as in epistaxis, bleeding often stops after its inhalation.
- Haemostatics* The use of horse serum has not justified its recommendation as a haemostatic, but good results have been reported from (i) the intravenous injection of calcium salts (e.g. 10 c.c. of a 5 per cent solution of calcium chloride, or 10 c.c. of a 10 per cent solution of calcium gluconate or levulinate); (ii) the intravenous injection of Congo red (5 to 10 c.c. of a 1 per cent solution repeated if necessary in four to six hours); and (iii) the oral administration of calcium salts and other drugs; but the assessment of their value is difficult on account of the uncertain course of haemoptysis. In some cases the bleeding has been arrested by the direct injection of a solution of blood-platelets (coagulen) into the pulmonary cavity (Morland). The application of an ice-bag to the chest probably has more psychological than any other effect, but is not likely to do any harm unless the patient is somewhat collapsed from loss of blood.

The patient should rest on the affected side, so that aspiration of blood should be limited to this side as much as possible. He should be encouraged to bring up blood but not otherwise to cough or talk, and as a general rule should remain in bed until the sputum is free from blood. The diet should be light, and alcohol is not advisable. The after-treatment is that of the underlying cause. *General treatment*

In 1885 Cayley employed artificial pneumothorax and collapse of the lung, and this method of giving rest to the affected lung is recommended when it seems certain from which lung the bleeding is taking place. This information can usually be obtained by the methods described on page 134, but, when doubt still exists, it is usually safe to collapse, by means of artificial pneumothorax, the side of the older lesion, especially if this contains a cavity. *Surgical treatment*

Thoracoplasty may be necessary for the treatment of recurrent haemoptysis but should be delayed until the patient's strength has been well built up after the haemorrhage. Phrenic evulsion is insufficient in most cases to close a thick-walled cavity, but may be useful as a temporary means of giving additional rest to the affected side, and thus of reducing the risk of haemorrhage, until the patient's condition is good enough to justify thoracoplasty. When only an apical thoracoplasty is required, the phrenic nerve should be temporarily interrupted by crushing rather than permanently by evulsion.

Lobectomy or pneumonectomy may be required in cases of bronchiectasis or chronic pulmonary abscess associated with haemoptysis. Pneumothorax and thoracoplasty do not give satisfactory results in this condition.

The treatment of the conditions that may give rise to haemoptysis is dealt with under the appropriate titles.

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HAEMORRHAGIC DISEASES

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Reference may also be made to the following titles:

BLOOD EXAMINATION	LEUKAEMIA
HAEMOPHILIA	SCURVY
SPLEEN DISEASES	

1.-DEFINITION AND CLASSIFICATION

596.] Knowledge of the haemorrhagic diseases is very incomplete. The symptoms are obvious and often dramatic, but the essential processes in their production are unknown. In some forms the causal factor is clear, as in the haemorrhages which follow snake bite or a deficiency of vitamin C; in others there is a well marked pathological factor, as in haemophilia (see p. 123). Even in such cases it is not known why blood does not clot or how it can escape so rapidly in the absence of definite discontinuity of vessels; but in a large group of haemorrhagic diseases there are not any undisputed factors or even a nomenclature under which to discuss them.

The term haemorrhagic diathesis is applied to a condition in which spontaneous extravasation of blood tends to take place into the skin and other tissues and from the mucous membranes. The haemorrhages may recur over many years with intermissions or throughout life, and the tendency may be hereditary; but in other cases the haemorrhages develop suddenly without any warning. The term primary purpura has been used for this condition but is not descriptive of it, as purpura refers only to small extravasations into the skin or mucous membranes and does not express the wide-spread haemorrhagic manifestations which develop, nor is purpura invariably present. In the true haemorrhagic diathesis haemorrhages may occur spontaneously from any site. Purpura should never be regarded lightly, for even a few transient purpuric spots are evidence of some general dyscrasia.

In addition to this primary group there are cases in which similar haemorrhages occur in the course of some other disease, such as leukaemia, and this type is commonly referred to as secondary or symptomatic purpura. The manifestations may be indistinguishable from those in the primary haemorrhagic diathesis.

Other haemorrhagic diseases exist, such as haemophilia, which is distinguished by several well recognized features, especially the sex-linked inheritance, and the importance of vitamin deficiency is daily becoming clearer. Intermediate and doubtful cases are met with which do not fall into any group, but the following classification may be accepted on our present knowledge:

(A) Primary non-hereditary haemorrhagic diathesis: (i) Purpura

haemorrhagica: (a) acute; (b) chronic. (ii) Anaphylactoid purpura; this includes the two syndromes known as Henoch's purpura and purpura rheumatica. (Schönlein's disease and peliosis rheumatica are synonyms for the latter type.)

(B) Symptomatic haemorrhagic states or secondary purpura, which may be associated with the following conditions: (i) Infectious fevers, in which the haemorrhagic state may appear in three forms: (a) the eruption in certain infectious fevers may be haemorrhagic, as in typhus, cerebro-spinal fever, and smallpox; (b) certain fevers may occur occasionally in a haemorrhagic form, for example scarlet fever and measles; (c) a haemorrhagic state of great severity may develop during convalescence from infectious fevers. (ii) Septic infections (e.g. septicaemia and pyaemia, infections with the pyogenic cocci, bacterial endocarditis). (iii) Diseases of the blood-forming tissues (e.g. leukaemia, aplastic anaemia). (iv) Organic and inorganic poisons (e.g. arsphenamine and its derivatives, gold sodium thiosulphate, certain benzene derivatives, iodides, quinine, belladonna, and other drugs; snake poison; proteins). (v) Cachectic conditions (e.g. associated with neoplasms, uraemia, old age, miliary tuberculosis). (vi) Acute necrosis of organs, exemplified by acute yellow atrophy of the liver; the necrosis may be due to syphilis or some toxins. (vii) Mechanical disturbances, such as venous stasis or severe muscular contractions (e.g. in whooping-cough, epilepsy, tabes, peripheral neuritis).

(C) Haemorrhagic deficiency disorders: (i) scurvy; (ii) melaena neonatorum.

(D) Hereditary haemorrhagic disorders: (i) haemophilia; (ii) hereditary haemorrhagic diathesis, including fibrinopenia and types intermediate with haemophilia; (iii) hereditary capillary telangiectasia.

2.—PRIMARY NON-HEREDITARY HAEMORRHAGIC DIATHESIS

(1)—Aetiology

597.] This diathesis is somewhat commoner in females than in males. The onset of the chronic or the acute form may occur at any age but is commonest between 5 and 15 years. The sporadic form alone is considered here, the hereditary group being dealt with separately (see p. 153). In these sporadic cases no exciting factor may be recognizable either in the acute type or in the exacerbations of the chronic type. The symptomatic group shows that similar manifestations may be provoked by a definite stimulus in some persons, and care must be taken that such a stimulus, which may be discontinuous, is not overlooked, but it must be accepted that there may be no exciting stimulus which is at present known. The relation of vitamin C deficiency is uncertain. No clinical feature, except previous attacks, can be recognized which gives warning that the haemorrhagic manifestations may develop in the acute type.

(2)—Pathogenesis and Morbid Anatomy

The factor which causes or permits the blood to leave the vessels is still uncertain. The coagulability of the blood is not at fault, as there is not any constant tendency to a prolonged coagulation-time, which is often shorter than normal. Nor are there any constant changes in the blood-cells. The possible factors which need special consideration are: (a) *Causal factors* blood-platelets; (b) permeability of the capillary walls; (c) bone marrow and blood-cells; and (d) spleen.

(a) *Blood-Platelets*

The blood-platelets normally help to prevent capillary haemorrhages by adhering in masses to the intima at weak or damaged spots, and it is possible that the blood tends to clot upon this mass as on any foreign body. *Adherence to intima*

The part played by the platelets in the clotting of normal blood is uncertain. The blood taken from a normal person after a meal will still clot if the platelets are removed (therefore platelets are not essential for clotting), but it will not do so if taken from a fasting person. Some factor essential for clotting is evidently added to the blood after digestion. During the artificial removal of the platelets this factor may also be partly removed, and during fasting it may be reduced below the necessary threshold. Nothing further is known about this factor. *Clotting*

With regard to the part played by the platelets in the haemorrhagic diathesis, the following facts have been established:

(i) The blood-platelets are diminished in number when capillary haemorrhages are taking place to a marked degree, or to a moderate degree over a long period. When the haemorrhages are very severe the platelets are reduced to a very low figure or completely absent. In more moderate states the platelets are usually between 50,000 and 120,000 per c.mm. These variations in the platelets apply to all types of capillary haemorrhage, primary or secondary, and Hayem recognized that the platelets were diminished in secondary purpura. Frank asserted that the platelets were not reduced in any form of haemorrhage or purpura, except the severe type to which the term purpura haemorrhagica was formerly confined. He believed that this type was distinct from all other types and was due to a primary essential absence of platelets and consequently named it essential thrombocytopenic purpura haemorrhagica. Although these views have been completely disproved, they are often repeated, and the name is still sometimes used. It is clear that the fall in platelets is not the primary factor but is probably secondary to the capillary haemorrhages, possibly from their consumption in blocking weak spots; but their diminution or absence removes a line of defence against the haemorrhagic tendency. *Diminution of platelets*

(ii) In established chronic cases of the haemorrhagic diathesis there may be intermissions during which haemorrhages do not occur although platelets are completely absent. During acute exacerbations the *Intermissions*

haemorrhages may cease while platelets are still absent, the cessation being followed by a rapid rise. Conversely, during intermissions the platelets may reach a considerable quantity, and haemorrhages may begin while they are still at such a point, a fall rapidly following. Bedson produced an anti-platelet serum which could completely remove all platelets from an animal's blood, but no haemorrhages followed.

*Coagulation
time*

(iii) The coagulation time in the haemorrhagic diathesis is usually within normal limits. In moderate cases it is often shorter than normal, but in severe cases with complete absence of platelets it may be somewhat prolonged, although never approaching the length in haemophilia. Animal experiments in which platelets have been removed from the blood give the same results, the coagulation time in the complete absence of platelets never exceeding two or three times the normal length. These facts show that diminution or absence of platelets cannot be the essential factor in the haemorrhagic diathesis, nor do these changes distinguish the primary from the secondary forms.

(b) Permeability of the Capillary Walls

*Increased
permeability
to blood*

There is no doubt that there is increased permeability of the capillary walls in haemorrhagic diseases. Any other explanation is impossible, for the haemorrhages develop spontaneously and without trauma, and it has been proved that haemorrhages do not necessarily occur in the absence of the protection afforded by platelets. The observations of Lewis and of Bedson show that the vessels are dilated and that there is no slowing of the blood-stream. Probably the defect is inability of the smaller vessels to contract properly; Bedson observed the blood passing through the capillary walls by 'an exaggerated process of diapedesis'.

The permeability is in part remedied by the adhesion of the platelets to the permeable sites, the number of circulating platelets thus falling, whereas if they are already absent from the blood the tendency to haemorrhage is greatly increased.

*Increased
permeability
to plasma*

The capillary permeability to blood-cells is closely akin to the permeability to plasma which occurs in urticaria and which may be produced by the injection of histamine; and as might be expected urticarial areas are often present in the haemorrhagic diseases, especially in the milder grades. The permeability may develop with extreme rapidity in a previously normal subject, as may be seen in the haemorrhages following snake bite and in the urticaria in sensitive persons after the injection of protein.

(c) Bone Marrow and Blood-Cells

There are no constant changes in the marrow, which may be normal, hyperplastic, or hypoplastic. Nor is there any characteristic blood picture; anaemia is usual, but in milder chronic forms it is not invariable, and in some forms the red cells are occasionally even above normal. The leucocytes may be increased or diminished in number, and there is not any constant differential count. The changes in the bone marrow

and blood-cells are consistent with their being secondary to the haemorrhagic state.

(d) *Spleen*

It is difficult to assess the part played by the spleen in the haemorrhagic diathesis. It is often, though not invariably, enlarged, especially in the chronic forms, but this may be so in any form of chronic anaemia, and in general the larger the spleen the less severe are the haemorrhages. There is nothing specific in the morbid anatomy.

Splenic enlargement

Removal of the spleen has usually a marked effect on the haemorrhages. In some chronic cases the haemorrhages cease immediately and permanently; in others the haemorrhages persist for a time but gradually cease; in yet other cases relapses develop after varying intervals of freedom; and occasionally the operation is not followed by any improvement. The haemorrhages do not always recur, even when the platelets are completely absent after splenectomy.

Effect of splenectomy

It has been suggested that in the haemorrhagic diathesis the spleen and associated reticulo-endothelial tissue produce a substance (of the nature of histamine) which is responsible for the capillary permeability. The removal of the spleen may or may not reduce the amount of this substance below the haemorrhagic level.

Reticulo-endothelial factor

(3)—Classification

Increased capillary permeability may result in the effusion into the soft tissues of (i) plasma only; (ii) whole blood; or (iii) plasma at some sites and blood at others.

Effects of increased permeability

If there is effusion of plasma alone, the manifestations of urticaria will result, in which, in addition to the cutaneous and subcutaneous swellings, there may be pain and swelling of joints, and abdominal pain and colic often accompanied by diarrhoea due to exudations into deeper tissues and intestines. The manifestations are not associated with the development of anaemia, and recovery even from a severe attack is rapid. (See Vol. I, p. 317.)

Effusion of plasma alone

If there is effusion of blood, the haemorrhagic manifestations will appear and will generally be associated with the development of anaemia.

Effusion of blood

Haemorrhages are of all grades of severity from purpura simplex to purpura haemorrhagica; unfortunately there is no recognized name for this group; the term purpura haemorrhagica is sufficiently satisfactory if it is agreed that it does not denote any particular degree of severity, and it will here be used in this sense.

If there is effusion of plasma at some sites and blood at others, the manifestations of both forms will be present simultaneously, as is often seen. Usually one or other type predominates, and there is much plasma with little blood or much blood with little plasma.

Effusion of plasma and blood

Four types of primary purpura have been commonly described: purpura simplex, purpura haemorrhagica, Henoch's purpura, and

*Purpura
haemorrhagica*

*Purpura
simplex*

*Henoch's
purpura*

*Anaphylactoid
purpura
Purpura
rheumatica*

purpura rheumatica. The term purpura haemorrhagica has been applied to the acute and very severe forms, to which also (as mentioned above) the term essential thrombocytopenic purpura haemorrhagica was given by Frank. Purpura simplex and purpura haemorrhagica are correctly only grades in severity of the same condition, that in which there is effusion of whole blood, but the terms, although not inconvenient, do not leave any title for the common cases of intermediate severity or chronicity.

The term Henoch's purpura is applied to cases in which abdominal symptoms are prominent. The French have long recognized that in this state the effusion of plasma is greatly in excess of the effusion of blood and have employed the term anaphylactoid purpura to include both Henoch's purpura and purpura rheumatica (Schönlein's peliosis rheumatica), in which the joint symptoms are most prominent.

The symptoms of the haemorrhagic diathesis will be described under (i) acute purpura haemorrhagica, (ii) chronic purpura haemorrhagica, and (iii) anaphylactoid purpura, including Henoch's purpura and purpura rheumatica or Schönlein's disease.

(4)—Acute Purpura Haemorrhagica

(a) *Aetiology*

598.] This condition may develop in either sex and at any age but is commonest in childhood. Milder manifestations of a haemorrhagic nature may or may not have been observed previously. Malaise may have been sufficient to attract attention for a few days previous to the onset of the haemorrhages, and occasionally anaemia has developed without any obvious cause, but usually the prominent haemorrhagic manifestations are sudden in onset and rapidly progressive.

(b) *Clinical Picture*

Haemorrhage The haemorrhages may be of any or all types, including purpura, ecchymoses, and extensive bleeding from one or more mucous membranes. The constitutional disturbances rapidly become severe. The pulse is rapid, and fever is usual and may be high but is irregular and does not follow any definite course. In addition to the haemorrhages there may be evidence of the effusion of plasma at various sites with or without abdominal discomfort and pains in the joints as in anaphylactoid purpura. The spleen is rarely palpable at the onset but may become so during the course; it does not attain any large size and is not of any special importance. The lymphatic glands are not involved.

*Effusion of
plasma*

Spleen

(c) *Blood Changes*

Blood-cells

Diminution of red cells and of haemoglobin is invariably present and advances rapidly, reaching an extreme grade; the colour index may be high or low. The leucocytes may be increased or diminished, and occasionally the numbers, especially of the granular cells, may fall so low as to suggest leukaemia or agranulocytosis.

The platelets are greatly diminished, usually under 30,000 per c.mm., and often disappear completely. When the number is small, the platelets present are often of unusually large size. *Blood-platelets*

Coagulation time is in the neighbourhood of the normal limits; thus it may be somewhat shorter or, more commonly, somewhat longer than normal. *Coagulation time*

Clot retraction is usually irregular, and the blood may clot without expressing any serum. This phenomenon also occurs in many states without any relation to the haemorrhagic diathesis and at present is little understood. *Clot retraction*

The capillary resistance (Rumpel-Leede) test and Duke's test of the bleeding time (see also Vol. II, p. 483) provide definite evidence that the haemorrhagic tendency is present and active. In the capillary resistance test the arm is constricted with a sphygmomanometer armlet at a pressure of 70 mm. for two minutes. If the haemorrhagic state is active, petechiae appear below the constriction either immediately or within one to two minutes. *Capillary resistance test*

The results of these two tests do not bear any direct relation to the coagulation time or to the number of platelets, but they show, especially Duke's test, that the haemorrhagic tendency is active at the time of examination.

(d) *Course and Prognosis*

The haemorrhages may continue with increasing severity, and anaemia becomes extreme and the pulse rapid and feeble. There is great discomfort from the painful bruises; and stomatitis and haemorrhages from the mucous membrane of the mouth may also be troublesome. The patient may sink into coma, and death may take place within a few days from coma or occasionally from cerebral haemorrhage, but most patients recover even in the absence of specific treatment. There is a chance of recovery in every acute case, because the haemorrhages may cease suddenly at any stage, the constitutional symptoms rapidly improving, although recovery is retarded by residual anaemia. The cessation of the bleeding may be difficult to recognize immediately owing to the haemorrhages already present, but the bleeding time is an absolute guide, as it is strictly parallel with the haemorrhagic tendency and may fall to normal in a few hours. It is the essential guide to the more important methods of treatment and must not be performed unnecessarily, as the lobe of the ear is the only convenient site and ecchymoses may render the test impossible to perform. Residual anaemia usually responds rapidly to treatment. Permanent disabilities may remain from haemorrhages into the tissues of the central nervous system, the eye, or other vulnerable sites. After an acute attack there is sometimes a chronic tendency to haemorrhage, but there may be freedom from all symptoms for many years until a recurrence may reveal the persistence of the haemorrhagic tendency. *Cause of death*

Recovery

Bleeding time as a guide

Permanent disabilities

(e) Diagnosis and Differential Diagnosis

The diagnosis is rarely difficult. Examination of the blood-cells will usually rapidly differentiate the blood diseases, such as leukaemia, but very rarely there is a close resemblance to aplastic anaemia and lymphoid leukaemia with leucopenia. Haemophilia is distinguished by the previous history, the coagulation time, the absence of purpura, and the fact that the bleeding, when the site is visible, consists of a steady ooze at a site of trauma.

Differential diagnosis from haemophilia

Resemblance to anaphylactoid purpura

Recognition of predisposing factors

There is no object in attempting to differentiate purpura haemorrhagica from anaphylactoid purpura in doubtful cases. The similarity of the pathogenesis has already been referred to, and all intermediate grades are met with.

It is important to ascertain if there are any predisposing factors such as are associated with secondary or symptomatic purpura, as this may affect decisions as to treatment, but the clinical manifestations of the primary and secondary groups are not distinguishable.

(f) Treatment

Local treatment

Snake venom

General treatment

Blood transfusion

Grouping

Technique

Splenectomy

Local treatment is only of use for checking gross haemorrhage from a mucous membrane. Reasonable pressure may be applied, but if this is too severe and too prolonged it may produce necrosis of the tissues. Coagulant snake venom is under trial, and the results so far have been very promising, the most potent being the venom of Russell's viper. This is used in a dilution of 1 in 10,000 and is applied with a gauze dressing. The bleeding site must be carefully cleansed first and clots gently removed.

General treatment aims at aborting the haemorrhagic tendency temporarily or permanently. The specific measures which need careful consideration are blood transfusion and splenectomy.

Blood transfusion may end the haemorrhagic tendency, apart from its direct value to an anaemic subject. It should always be performed in all cases of acute purpura haemorrhagica immediately the diagnosis has been made. The blood must be carefully grouped, and cross grouping with the prospective donor should be performed (see Vol. II, p. 535), but the presence of auto-agglutinins in the patient's blood at room temperature is not a contra-indication to transfusion. The amount injected should be about 300 c.c. for an adult. (For technique see Vol. II, p. 536.) The bleeding time must be watched subsequently, and if a definite reduction does not occur in twelve hours blood transfusion should be repeated.

Splenectomy brings to an end the haemorrhagic tendency in a high proportion of cases, but the decision to operate must not be made lightly, owing to the serious operative mortality in acute forms. It must be borne in mind that many cases recover spontaneously, and in all circumstances blood transfusion must be tried first. Splenectomy may be considered if at the end of twenty-four hours and after two blood transfusions the haemorrhages continue, the bleeding time is still

excessive, the haemoglobin is falling, and the constitutional disturbances are becoming more severe.

A high platelet count would be a contra-indication owing to the risk of thrombosis, but thrombocytopenia is almost invariably present in the acute type. A blood transfusion should be performed immediately before operation.

Contra-indication

It is not easy to assess the results of operation, as many patients recover spontaneously and others would inevitably die. There is no doubt that the haemorrhages may cease almost instantly after splenectomy and the bleeding time become normal. The platelets rise rapidly, due to flooding of the circulation with reserves from the bone marrow, such as occurs after splenectomy for other causes. In favourable cases recovery from the operation may be uneventful and the haemorrhages entirely disappear. There may be freedom from recurrence over a period of years, but serious and intractable haemorrhages may begin again after long intervals of such freedom. In a few cases the platelets fail to rise, improvement does not follow, and the patient dies.

Results of operation

Other methods of treatment which have been used are injections of whole blood, so-called haemostatic preparations, horse serum, calcium salts, and liver extract, all of which may be regarded as valueless.

Other methods of treatment

Antiscorbutic treatment by the mouth is useless, but it is possible that intravenous injection of ascorbic acid may prove to be of value. This method is in an experimental stage: the published results are contradictory and the earlier records unconvincing. Miller and Rhoads reported four cases in which ascorbic acid (vitamin C) produced a persistent rise in the number of thrombocytes and complete relief of symptoms. Szent-Györgyi and his co-workers reported different results. They obtained no effect from the use of pure ascorbic acid; but from Hungarian red pepper and from lemon-juice they isolated a fraction to which they gave the name vitamin P, injections of which controlled the bleeding in certain cases of purpura with decreased capillary resistance. No effect was produced on other cases which they classified as thrombocytopenic purpura (Armentano).

Antiscorbutic treatment

Vitamin P

(5)—Chronic Purpura Haemorrhagica

(a) *Clinical Picture*

599.] It is difficult to give an adequate clinical picture of this group, in which every type of haemorrhage may occur in every grade of severity and chronicity.

Variations in severity and chronicity

There may be a few purpuric spots in a child without other disturbances or with slight joint pains and abdominal discomfort, but even with such mild manifestations the condition is constitutional and not local and may recur with increasing severity, and consequently the comfortable diagnosis of purpura simplex is a dangerous snare.

Recurrent attacks in a given person may be always of the same type, such as purpuric spots or epistaxis, or purpura with epistaxis or scattered ecchymoses, or they may be of different types, and the same

- subject in consecutive attacks may exhibit purpura, urticaria, and haemorrhages from mucous membranes. Some subjects are never free from purpuric spots or exhibit a tendency to 'bleed easily'. The spleen may be so big as to be easily palpable. In chronic cases an acute attack may supervene at any time and, whereas such an attack is rarely of extreme severity as in the primary acute form, it may be sufficient to induce in an already anæmic person a dangerous paucity of blood.
- Spleen*
- Oedema* Local areas of oedema from escape of plasma may develop also in this group. These are often ascribed to 'deep haemorrhages', but they may disappear rapidly without evidence of bleeding.
- Recurrent haemorrhages* It is now accepted that recurrent haemorrhages from the same site may be a manifestation of the haemorrhagic diathesis. The commonest forms are recurrent epistaxis, hæmaturia, and menorrhagia and metrorrhagia, and the possibility of the haemorrhagic diathesis must be remembered in such conditions.
- Sites of hæmorrhage* Haemorrhages may take place into important structures. Thus haemorrhages into the retina and other structures of the eye are not uncommon and may take place gradually during chronic stages; the diagnosis may be made by an ophthalmologist. Cerebral hæmorrhage is an occasional termination but is uncommon except in an acute exacerbation. Haemorrhages into the spinal cord are rare.

(b) Blood Changes

- Blood-cells* The changes in the blood-cells may be of any degree, but owing to the chronicity the diminution in hæmoglobin, red cells, and white cells may be out of proportion to the extent of the haemorrhages at the time of examination. During intermissions the red cells are occasionally above normal. The reticulocytes may form 10 per cent or more of the red cells.
- Platelets* In chronic cases of moderate severity the platelets are often between 100,000 and 150,000 per c.mm. The further the numbers fall below 100,000 the more severe will the haemorrhages probably be in the event of an acute exacerbation.
- Capillary resistance and bleeding time* The capillary resistance test and the bleeding time show whether or not the haemorrhagic tendency is active at the time of examination, and it is important to understand the significance of these two tests. In a subject of the chronic haemorrhagic diathesis intermissions occur during which the tendency to haemorrhages is not active, and during such periods the capillary resistance test and the bleeding test will be negative. Hence negative tests do not prove that an individual is not a subject of the diathesis but only that it is not active.
- The two tests compared* The capillary resistance test is the most sensitive and may be positive when the bleeding test is negative, when no haemorrhages have recently occurred and no purpuric spots are visible. The bleeding time is more easily used quantitatively and runs parallel with the degree of hæmorrhage occurring at the time and thus is of particular value in determining the need for special methods of treatment.

(c) Course and Prognosis

The haemorrhages may continue or recur throughout life, and the effects will depend on their severity, site, continuity, and exacerbations. Some subjects suffer inconvenience mainly from the resulting anaemia: leucopenia is a sign of exhaustion of the bone marrow. As with slowly developing anaemia from any cause, it is surprising how much physical activity is compatible with a high grade of microcytic anaemia.

*Factors
determining
Prognosis*

Other patients suffer from the continual discomfort of ecchymoses or from the recurrent haemorrhages from the mucous membranes. Haematomas not uncommonly become septic. As already mentioned, the haemorrhages may damage important structures, such as the eye or ear.

The haemorrhages generally diminish in later life, but this is not invariably so, and acute exacerbations may occur at any age.

(d) Diagnosis and Differential Diagnosis

The diagnosis is usually simple, if the case has been under observation for any length of time. The occurrence of purpura over a course of years is not consistent with any other condition. Purpura, however, is not invariably present. Special care must be taken in the diagnosis in cases in which the haemorrhages are confined to a single mucous membrane, such as haematuria or menorrhagia, and the diagnosis of the haemorrhagic diathesis should only be made when a long bleeding time, a positive capillary resistance test, and a diminished platelet count are recorded.

In addition to conditions mentioned under the acute form the distinction from the ill defined group known as splenic anaemia may be very difficult. In well defined cases of splenic anaemia purpura is not present, but intermediate forms are met with in which the differential diagnosis remains uncertain.

*Differential
diagnosis*

*From splenic
anaemia*

Haemophilia is easily excluded by the prolonged coagulation time and the entire absence of purpuric spots.

*From
haemophilia*

As with the acute form, there is no object in attempting to make a diagnosis from anaphylactoid purpura, but every care should be taken to exclude any predisposing cause and to differentiate this form from the symptomatic and secondary groups.

(e) Treatment

The problem of treatment differs from that in the acute group, as there will be ample time for observation and there can be no expectation that the haemorrhages will cease spontaneously.

Splenectomy has been successful in many of these cases and must always be considered. The operative mortality is about 8 per cent.

Splenectomy

The first question is whether or not the condition is sufficiently severe to warrant the risk of the operation. In some cases the haemorrhages constitute only a moderate disability. In others a reasonably active life

*Indications
for operation*

may be possible with the assistance of an occasional blood transfusion. If operation cannot be dismissed on these grounds consideration must be given to the age of the patient, the general physical condition, the previous history, the severity of the haemorrhages, the degree of anaemia, and evidence of increasing severity.

*Risk of
thrombosis*

If the blood-platelets are above 150,000 per c.mm. this should weigh against splenectomy owing to the risk of subsequent thrombosis, whereas if their number is below 100,000 this should weigh in favour of the operation. The bleeding time is of little value. It may be normal in periods of intermission, but there is not any evidence that haemorrhages will not recur.

*Results of
operation*

As to the results of splenectomy, many cases have been permanently cured. The haemorrhages may cease immediately or may continue in a slighter degree for some months before ceasing. In some subjects the haemorrhages continue permanently in a greatly diminished severity. As in the acute cases, severe haemorrhages have been known to develop after freedom for several years. The constitutional diathesis remains, and the capillary resistance test has been found to be positive after prolonged absence of symptoms. In favourable cases the platelets usually rise to a high level after operation and subsequently fall to within normal limits. Occasionally the platelets fall to a low level in a few weeks, and although the haemorrhages may be absent they will always return later. In a few cases there is no improvement and no effect on the blood or the platelets.

*Irradiation
of spleen*

Irradiation of the spleen has been used on many occasions. Mettier and Stone recorded six cases of idiopathic thrombocytopenic purpura thus treated. The platelets rose rapidly and the clinical condition improved. The method, however, has often failed to produce benefit.

*Protein
shock*

Among other treatments which have been tried is protein shock by the injection of T.A.B. vaccine or tuberculin. This method is not free from danger, and some bad results have been recorded. Injections of adrenaline have occasionally been successful in children. Applications of ultra-violet light are useless.

Adrenaline

(6)—Anaphylactoid Purpura

(a) Definition

*Henoch's
purpura and
purpura
rheumatica*

600.] Under this title are included both Henoch's purpura and purpura rheumatica (Schönlein's peliosis rheumatica). Schönlein left no written account of his syndrome, and after his death his pupils disagreed as to what he had described.

(b) Aetiology

The symptoms commonly begin in childhood but may primarily arise in adult life or persist into it, and the disease is not confined to childhood.

(c) Clinical Picture

In order to obtain a clear picture of this syndrome it must be borne in mind that the essential pathology is the escape of plasma from the vessels, the escape of blood-cells being comparatively slight. Thus in the skin and superficial tissues there will be found tender swellings without evidence of haemorrhage. These are often ascribed to 'deep haemorrhages', but they often subside rapidly without any evidence of the presence of blood. The face may be sufficiently puffy to suggest nephritis. The escape of a considerable amount of plasma may be accompanied by or cause the escape of a small amount of blood-cells, which will stain the plasma and produce an extensive 'ecchymosis' suggesting more free blood than is actually present. The appearance can be readily produced by the injection of 1 to 2 c.c. of physiological saline subcutaneously. True purpura is absent or scanty, and haemorrhages from the mucous membranes are not a prominent feature.

*Skin**Face**Mucous membranes*

Similar unstained or stained areas of plasma are also found in the other forms of the haemorrhagic diathesis but to a less degree.

In anaphylactoid purpura attacks of abdominal pain and colic are common and may be accompanied by vomiting and by diarrhoea, often with passage of blood. These attacks can be ascribed to oedematous areas in the viscera, and these have been seen during exploratory operations. Pain and swelling of joints are also common. Such a swelling may appear suddenly and subside almost as rapidly, only to be followed by a similar swelling in another joint. The heart is unaffected.

*Abdominal symptoms**Swellings in joints*

Constitutional disturbances are often severe, owing to the abdominal symptoms and the tenderness of the numerous swollen and ecchymotic areas, and the patient may be said to be more sick than purpuric or haemorrhagic. The spleen may be just palpable.

*Constitutional symptoms**(d) Blood Changes*

The blood changes vary with the amount of haemorrhage and not with the severity of the anaphylactoid manifestations or the constitutional disturbances. There is usually a moderate degree of anaemia but this is not invariable, and the red cells may be normal. The blood-platelets are often reduced to 100,000 to 150,000 per c.mm. but may be normal or above normal, and the capillary resistance and bleeding time tests may be negative, even while symptoms are present.

(e) Course and Prognosis

When an active stage has become manifest, recurrences may take place over many months. Recovery from an attack is often surprisingly rapid, there being no residual anaemia to deal with, and no ill effects remain. There is little information about the ultimate prognosis, but there is no doubt that the tendency to attacks often diminishes in later life. Intussusception may develop from the invagination of an oedematous and haemorrhagic area of intestine and on many occasions has been found

Intussusception

at operation. The symptoms of intussusception may be closely simulated in its absence, blood and mucus being passed in the stools, and the diagnosis may be very difficult. Appendicitis is also an occasional complication.

*Intracranial
oedema*

Intracranial oedema may develop and may be fatal, the symptoms closely resembling those of uraemia. This complication together with the oedema of the facies (see above) is probably the origin of the statement that these cases and those of the other groups of the haemorrhagic diathesis often die of nephritis, for which there does not appear to be any substantial evidence. Urticaria may have a similar ending.

There is no dividing line from the other groups of the haemorrhagic diathesis; a subject of anaphylactoid purpura may develop manifestations of acute or chronic purpura haemorrhagica at any time.

(f) *Treatment*

The general principles of treatment which have been discussed in acute and chronic purpura haemorrhagica apply also to this type. The escape of blood is often slight, and the anaemia may be correspondingly moderate and the blood-platelets high, but the diagnosis of anaphylactoid purpura is not in itself a contra-indication to splenectomy, and the decision to operate should be made on the same grounds as in the previous groups.

Horse serum

In view of the anaphylactoid factor injections of horse serum have been much used and in some cases have appeared to influence the albuminuria, but the benefit is transient.

3.—SYMPTOMATIC HAEMORRHAGIC STATES OR SECONDARY PURPURA

601.] This group differs essentially from those already discussed inasmuch as a primary cause or factor is present. The influence of this factor varies greatly, as in some cases it may be still continuing, whereas in others it has ceased and is non-recurrent. The importance of the manifestations also varies greatly in different conditions.

*Infectious
fevers*

The eruptions may become haemorrhagic or a haemorrhagic tendency may develop at the time of the rash in many of the specific fevers. In some cases the eruption has faded and the patient apparently entered convalescence before the haemorrhages begin. In both of these forms the haemorrhages may be of great severity, known as purpura fulminans, and death may follow within one or two days, but the haemorrhages may cease at any point and improvement rapidly take place. The indication is to tide over the acute period if possible, as the stimulus is non-recurring and recovery, when it takes place, is permanent without subsequent tendency to haemorrhages. Splenectomy is contra-indicated as in all forms of secondary purpura. Blood transfusion, on the other hand, should be performed immediately.

*Purpura
fulminans*

*Splenectomy
contra-
indicated*

The haemorrhagic manifestations in septic infections are often little more than an accident, e.g. in the course of a streptococcal septicæmia or chronic bacterial endocarditis. Foci of sepsis may be a factor in the development of less severe grades of haemorrhage, and subsequently such foci should always be sought for and corrected as far as possible. *Septic infections*

Haemorrhages may occur in the later stages of most disorders of the blood-forming tissues, such as leukaemia and aplastic anaemia. *Blood disorders*

The influence of certain organic and inorganic poisons in producing haemorrhages has long been known. There is little doubt that certain of the benzene derivatives may produce haemorrhages in susceptible persons. Information is at present scanty, but many of the compounds which produce agranulocytosis may have this effect. *Organic and inorganic poisons*

In cachectic states, e.g. in advanced neoplasms, haemorrhages are probably due to weakness of the capillary walls and are only an incident in the state of debility. *Cachectic conditions*

4.—HAEMORRHAGIC DEFICIENCY DISORDERS

602.] (i) Scurvy is dealt with under the title SCURVY.

(ii) Melaena neonatorum is a curious condition which occurs in newborn infants between the third and tenth days. It is not hereditary, has no relation to the haemorrhagic diathesis, and is apparently distinct from haemophilia. The pathogenesis is unknown, but it is probably due to deficiency of some substance. The bleeding is usually from the bowel but may be from any mucous membrane. *Melaena neonatorum*

The specific treatment is the intramuscular injection of 10 c.c. of whole blood. The blood can be drawn directly into a syringe from the vein of the mother or any healthy person and injected immediately, grouping being unnecessary. A single injection is often sufficient, but it should be repeated once or twice a day if the haemorrhages continue. Blood transfusion is only indicated if the amount of blood lost has been excessive. There is no subsequent tendency to haemorrhages. *Treatment*

5.—HEREDITARY HAEMORRHAGIC DISORDERS

603.] (i) Haemophilia is dealt with under the title HAEMOPHILIA (see p. 123).

(ii) Familial haemorrhagic telangiectasia is dealt with under the title ERUPTIONS, ANOMALOUS AND ATYPICAL (see Vol. V, p. 148).

(iii) Hereditary haemorrhagic diathesis. This group is much rarer than the non-hereditary form. The diathesis may be transmitted by both sexes and exhibited by both sexes. In many cases the manifestations are identical in every way with those in the non-hereditary group, and it is difficult to know whether they should be regarded as having a

Splenectomy different pathogenesis. It has been said that splenectomy is contra-indicated in hereditary cases, but there is a family on record in which the father was operated upon with complete success many years ago, but the child died after splenectomy without any rise of the blood-platelets. On the whole, it is best to neglect the hereditary factor and to consider the treatment of the hereditary group on exactly the same lines as that of a non-hereditary form.

Intermediate forms In the hereditary group there are cases which do not conform exactly to the usual manifestations of the haemorrhagic diathesis, and many of these appear to be intermediate between the haemorrhagic diathesis and haemophilia. Thus the diathesis may be transmitted through males and exhibited by both sexes, and the coagulation time may be considerably prolonged, whereas the blood-platelets may be normal and the bleeding time variable. In such a case the normal number of platelets would contra-indicate splenectomy. Many different kinds of the manifestation exist, and each case must be judged differently on the principles already enunciated. During an acute attack it can never be wrong to give a blood transfusion. Cases of a similar character occur without a hereditary factor and have to be dealt with on the same principles.

Fibrinopenia In a very rare group of cases, the so-called fibrinopenia, the tendency to haemorrhage is due to a deficiency of fibrinogen in the blood. No treatment is known which will remedy this deficiency.

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HAEMORRHOIDS

See RECTUM DISEASES

HAEMOTHORAX

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Reference may also be made to the following titles:

ANEURYSM

LUNG DISEASES

EMPYEMA

MEDIASTINUM DISEASES

1.—DEFINITION

604.] Haemothorax is a collection of blood in the pleural cavity. The term, strictly used, does not include haemorrhagic effusions, though the distinction is somewhat artificial, as blood may become diluted by serum and a serous effusion may be very heavily charged with blood.

2.—AETIOLOGY

Causes

True haemothorax is not common in civil practice. Its most usual cause is accident involving fracture of ribs or crushing of the chest. Other rare causes are: rupture of an aneurysm of the thoracic aorta or other vessels, injury to an intercostal or other vessel during exploration, paracentesis, thoracoscopy or division of adhesions, or erosion from some inflammatory process or neoplasm. Haemothorax may be caused by malignant disease of the lung or pleura, and very rarely by spontaneous pneumothorax, due either to tuberculosis or to rupture of an

emphysematous bulla, the bleeding in both cases being caused either by a ruptured adhesion or by a ruptured pulmonary blood-vessel. Other causes, also rare, are infarct, purpura, scurvy, haemophilia, the malignant type of exanthemata and other infections, and multiple angiectases of the pleura. Haemothorax has been reported in association with cirrhosis of the liver and granular kidney; and an extremely rare condition of recurrent and even bilateral haemothorax of unexplained causation has been called pachypleuritis haemorrhagica.

In warfare haemothorax is common, wounds of the chest being thus complicated in a large percentage of cases.

3.—CLINICAL PICTURE

The clinical picture will vary with the cause of the haemothorax, the suddenness and mode of onset, the amount of blood, and the presence or absence of infection. If the amount of blood is great, there will be the usual symptoms of severe internal haemorrhage, pallor, air hunger, collapse, restlessness, syncope, coldness of extremities, with a rapid pulse; if small, there may be no symptoms. Dyspnoea is sometimes a marked feature. With a ruptured aneurysm, death may be instantaneous or the patient may first experience severe pain, cry out, and then become unconscious. Temporary recovery is possible; but, as a rule, in the course of a few hours or days there is a recurrence which is fatal.

*Varia-
tions
in clinical
picture*

Dyspnoea

Frequently, however, in traumatic pneumothorax, unless the haemorrhage is continuous or recurrent or infection has occurred, the patient, after recovery from pain and shock, may be surprisingly comfortable. With an infected haemothorax, symptoms of progressive toxæmia supervene.

If an intercostal vessel is pierced during the passage of an instrument, or injured during operative procedures for the division of adhesions through the thoracoscope, nothing may be noted at first, but within a few minutes or even after several hours increasing pallor, restlessness, a quickening of the pulse, and possibly a rise of temperature may occur. A little bleeding will produce no symptoms, but severe and even fatal haemorrhages have been reported.

In haemothorax, whatever the cause, the temperature may be raised, 100° to 104° F., for some days, but if the haemothorax is sterile should begin to fall about the fourth day. It may, however, remain raised much longer in the absence of any recognizable sepsis.

Temperature

The physical signs are those of fluid, impaired resonance, sometimes skodaic resonance, absent or tubular breath sounds, absence of adventitious sounds, and diminished vocal resonance, though sometimes bronchophony and whispering pectoriloquy may be heard. If the amount of blood is considerable, the heart and mediastinum will be displaced to the opposite side.

*Physical
signs*

The diaphragm, contrary to what might be expected, is frequently

<i>Displacement of diaphragm</i>	displaced upwards. Of this phenomenon various explanations have been given, such as massive collapse of the lower lobe, phrenic paresis, and so on. It is not confined to haemothorax, however, but may be observed not infrequently in acute pleural effusions, when the diaphragm may rise quite considerably and not descend or begin to function until the fluid is absorbed. It would appear to be due to the paralysis of the diaphragm, but the mechanism which produces the palsy is not known.
<i>Abdominal rigidity</i>	Irritation of the diaphragmatic pleura will give rise to abdominal rigidity, particularly with an infected haemothorax; and the symptoms and signs do not differ from those observed commonly in diaphragmatic pleurisy, which lead occasionally to a mistaken diagnosis of perforated gastric ulcer or other abdominal emergency.
<i>Haemo-pneumothorax</i>	If a haemo-pneumothorax exists, whether due to an external wound or damage to the lung or to gas-forming anaerobes, the succussion splash will usually be present; if there are only localized collections of air, these will be seen on X-ray examination.
<i>Surgical emphysema</i>	Surgical emphysema is not infrequently present in traumatic cases.

4.—COURSE AND PROGNOSIS

<i>Ruptured aneurysm</i>	The course and prognosis depend on the cause. A ruptured aneurysm is usually rapidly fatal, but, as already stated, temporary recovery may occur.
<i>Traumatic haemothorax</i>	A small traumatic haemothorax will become almost entirely absorbed, leaving no sequelae, except perhaps some thickened pleura at the base and possibly an obliteration of the costophrenic sinus.
<i>Formation of clot or fibrin</i>	An untreated large sterile haemothorax may behave in several ways. Massive clots may form and sink to the most dependent part of the pleural cavity, the costophrenic sinus or the costovertebral gutter; or fibrin may be deposited in layers over the visceral and parietal pleura generally, causing a thickened pleura and a contracted lung. In fact, blood acts not unlike an ordinary serous effusion. This may cause little or no deposition of fibrin, or masses of snow-white fibrin may be produced, some being churned into rounded lumps; or the whole of both pleural surfaces and every adhesion may be thickly covered as with sugar icing, both of which phenomena are frequently observed during thoracoscopies.
<i>Calcification</i>	Calcification of a long-standing haemothorax can occur. Or again, such a haemothorax may remain uncoagulated for weeks or months even in the presence of air (haemo-pneumothorax).
<i>Cytology</i>	Haemolysis and a phagocytic reaction may occur, the cytology changing from a polymorphonuclear leucocytosis to a phase of large phagocytic cells, whose function is to take up the red blood-cells, and thence to a considerable eosinophilia. The remaining fluid finally becomes completely absorbed. In such a case the lung will re-expand almost perfectly.

The factors that determine these various modes of behaviour are not exactly known. It is probable that, with an intact pleural endothelium and with no foreign body other than the blood present, coagulation will not occur, just as blood will not clot when it is kept in an undamaged blood-vessel tied at each end. On the other hand, the blood may be whipped up and the fibrin separated, and blood-cells and haemolysed blood will colour the resulting serum. It is possible that the presence of adhesions may be a factor that produces the 'whipping' of the blood. In those cases of haemothorax in which clotting does not occur an anticoagulant has been postulated, but the nature of this is unknown. Blood withdrawn during the first few hours may clot, whereas that withdrawn later may not clot.

*Factors
determining
the course*

When there is an external wound, when there is infection, or when fragments of skin, rib, or clothing and so forth are driven into the pleural cavity, then clotting is an almost invariable rule.

With a successful aspiration, though some fibrinous thickening of the pleura may occur, the lung should re-expand and function perfectly. In any type of case, re-expansion of the lung will depend on the presence and extent of thickening of the visceral pleura, the amount of lung damage and scarring, and the measures for promoting lung expansion, especially paracentesis, negative pressure drainage (when drainage is necessary), and properly organized breathing exercises.

Prognosis

An infected haemothorax has a grave prognosis and early and radical treatment is indicated. This will be referred to later (p. 161).

*Infected
haemothorax*

With malignant disease, especially with secondary tumours of the pleura, enormous quantities of blood-stained effusion looking almost like pure blood may be produced. Repeated aspiration, or even drainage, is essential to relieve dyspnoea, and the patient steadily deteriorates, becoming progressively weaker, more anaemic and dyspnoeic, partly from loss of blood but also from secondary deposits in the mediastinum.

*Malignant
disease*

5.—DIAGNOSIS

The diagnosis is made by the history, the symptoms of internal bleeding, the physical signs of fluid, and exploratory puncture.

• In traumatic pneumothorax, if the blood is not completely aspirated, or if it recurs, frequent exploratory punctures are essential to detect the first signs of infection. The temperature may be no guide and it is dangerous to wait for signs and symptoms of toxæmia. A complete bacteriological examination, including both aerobic and anaerobic cultures, should be made. If the blood withdrawn has any odour, the case should be treated forthwith as an infected haemothorax even though bacteria are not found.

*Diagnosis of
infection*

In a ruptured aneurysm the sudden intense pain, shock, dyspnoea, and collapse, may suggest a spontaneous pneumothorax, and although the percussion note should in the one case be dull and in the other resonant,

*Diagnosis
from
spontaneous
pneumothorax*

in practice the most experienced may be in doubt owing to the peculiar type of altered resonance that may occur in both these conditions; the exploring needle will be the final arbiter.

6.—TREATMENT

*Of
progressive
bleeding*

If the bleeding is progressive, and if the bleeding point can be found and tied, this is the obvious treatment, but this combination of conditions is seldom likely to arise. In haemo-pneumothorax thoracoscopy might be of value.

*Instrumental
injury*

Instrumental injury to an intercostal artery, which is usually due to careless technique and a failure to observe the strict rule always to go close to the upper edge of the rib and to keep the point of the instrument down, should be treated by resecting a rib and securing and tying the bleeding artery. If the injury to the intercostal vessel occurs during thorascopic procedures, the bleeding point may be coagulated by the diathermy knob. It is important to keep the lamp and telescope away from the spurting or oozing vessel. If coagulation by diathermy is impossible, or if the bleeding cannot be controlled, a cannula should be inserted lower down and blood allowed to escape freely; after a time the bleeding will become less severe and the instrument may be re-inserted through the cannula, the bleeding point being coagulated either directly by the diathermy knob or indirectly by gripping it with forceps through which the diathermy current can be passed. If there is much loss of blood, a saline or blood transfusion may be given. Failing this, the only method is to open the chest and, if possible, secure the bleeding point. The essential precaution is to prevent bleeding by always coagulating before cutting any part that is vascular or liable to contain blood-vessels of any size.

*Ruptured
aneurysm*

In ruptured aneurysm, nothing can be done beyond administering palliative treatment. Opium in some form, or one of its derivatives, must be given in full doses, or evipan or similar substance must be given intravenously, to confer immediate relief from unendurable distress. It is usually stated that aspiration is dangerous; but, if it is necessary for the relief of suffocative dyspnoea, no purely academic consideration must prevail, for, as cure is not possible, alleviation of suffering must be the only objective.

*Malignant
disease*

For the large haemorrhagic effusion that may occur with malignant disease, repeated aspirations are required. X-ray irradiation to the affected side may be worth trying. If the patient becomes wearied of the repeated aspirations, a self-retaining intercostal catheter can be introduced through a cannula, under local or evipan anaesthesia. A spigot is inserted at the end of the tube, and this can be removed and fluid run off as required.

*Injuries and
wounds*

In injuries and gun-shot wounds, the whole problem is entirely different. Here there is hope of saving the life of the patient. If the bleeding is

still going on when the patient is first seen, surgical intervention will be needed and it may be possible to find and tie the bleeding vessel. Saline or blood transfusion may be needed. As a rule the bleeding has stopped before the patient reaches the hospital, field ambulance, or casualty clearing station. The question then arises whether or not to aspirate. The first thing is to relieve shock and pain and to give a long, refreshing sleep. After or during this paracentesis should be performed. The general consensus of opinion is that it is best to aspirate. This prevents formation of clot and fibrin and so promotes expansion of the lung. It lessens the danger of anaerobic infection. The objection has been urged that paracentesis, by inducing negative pressure, may cause a recurrence of bleeding. This is not borne out by experience, and in any event it is best to aspirate by air replacement. This was my invariable practice at a casualty clearing station through both battles of Cambrai in the War 1914 to 1918, where there were an exceptional number of rifle-bullet wounds of the chest, and it appeared to answer well. By this method a high negative pressure is not produced in the pleural cavity, there is no disturbance of the mediastinum, and all the blood, or most of it, can be withdrawn.

In an infected or a potentially infected haemothorax, with an open wound, in-driven splinters of bone, muscle, clothing and so forth, early surgical intervention is imperative. The first thing is immediately to close, if only temporarily, by any means, an open wound through which air is being sucked from the atmosphere into the pleural cavity, the next to adopt measures to relieve shock and collapse. After this, thorough surgical treatment is demanded: resection of rib, and clearing the pleural cavity of blood, blood clot, and foreign bodies. If the lung itself is torn and contains shell fragments or portions of ribs or clothing, this must be dealt with radically at the same time. The after-treatment is the same as that for a streptococcal empyema or a lobectomy. Negative pressure drainage should be employed and, as soon as possible, carefully graduated breathing exercises should be prescribed (see Vol. IV. p. 531).

*Infected
haemothorax
with open
wound*

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HAIR FOLLICLES, ABNORMALITIES AND DISEASES

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Reference may also be made to the following titles:

ALOPECIA	SEBORRHOEA AND SEBORRHOEIC
ELECTROTHERAPY	DERMATITIS
FUNGOUS DISEASES	

1.—INTRODUCTION

*Development
of hair
follicle*

605.] Since the shaft of the hair, after leaving the hair follicle, ceases to grow and is, to all intents and purpose, a dead structure, all changes in the extrafollicular portion of the hair shaft are due either to inherent defect at the time of its formation in the depth of the follicle or to some

injury received by the hair shaft outside. It is therefore more reasonable to apply the term abnormality to the follicle rather than to its product.

The hair follicles may be developed either abnormally strongly or abnormally weakly. In the former event the hair is unusually thick and abundant—hypertrichosis, and in the latter it may be very fine or completely absent. (See ALOPECIA, Vol. I, p. 337.)

2.—HIRSUTIES

(1)—Classification of Types

606.] Hypertrichosis (hirsuties) may be: (1) Universal or generalized, *Generalized* every part of the body being affected, e.g. the 'dog-faced' man. (2) Partial or localized. In this type there may be (a) circumscribed areas of hairiness on parts not usually very hairy, e.g. on the lower spinal region, associated with spina bifida; *Localized* (b) unusually abundant growth of hair on parts that normally show some hair, e.g. the forearms and lower legs; (c) growth of hair that is abnormal only in regard to the sex of the patient, e.g. on the upper lip, chin, submental region, cheeks, sternal region, forearms, and lower legs, in women; or (d) local excessive growth of hair in either sex combined with other abnormality of the skin, associated with moles, or in neurofibromatosis. Only the last two varieties are of any importance from the point of view of treatment, since the others are freak developments for which nothing can be done.

(2)—Hypertrichosis in the Female

(a) *Aetiology and Clinical Picture*

The abnormality may be divided into two types, one beginning between the ages of eighteen and twenty-five and the other becoming obvious in later life, usually at or after the menopause.

Early castration of the male results in the partial or total failure of development of the hair other than that of the scalp and, incidentally, prevents the development of the masculine type of baldness which begins at about the age of twenty. There is a tendency in women to develop hair on the face after the menopause. There appears therefore from these facts to be a connexion between the growth of hair on the face and the sex hormones. The matter is, however, far from simple. It is not uncommon to see an overgrowth of hair in an apparently healthy girl with normal sexual functions; she may marry at, say, twenty-two and give birth to a usual number of children whom she is able to feed at the breast satisfactorily, and yet the condition may progress steadily during the whole of her sexual life and not be aggravated by the onset of the menopause. *Relation to sex hormones*

Occasionally the hirsuties is associated with obvious abnormality in the function of the sex organs, but this is present in only a small proportion of the cases. From time to time, however, cases are recorded in which hormone treatment has been successful.

Some diseases of the adrenal glands are associated with precocious

Relation to disorders of adrenals

growth of the sexual hair, but, as these diseases are also associated with precocious sexual development, it is not certain that the growth of the hair is not stimulated secondarily by the sex hormones (see also Vol. I, pp. 218 and 247, and SEX HORMONES).

Association with acne

Lastly, in a small proportion of cases hirsuties is preceded by severe acne. The excessive growth cannot always be due to the treatment of the acne, for in many cases the acne has disappeared spontaneously without treatment. The causation of feminine hypertrichosis is therefore still obscure.

Effect of ultra-violet rays

Various local stimulants may have some effect in the production of hypertrichosis. Stimulation by ultra-violet rays tends to increase the local growth of hair. This has been observed repeatedly in the case of the light treatment of lupus. The local overgrowth subsides, however, a few months after cessation of the treatment.

Sun bathing

Patients with mild hypertrichosis often find that a prolonged stay in the tropics is followed by a rapid increase in the condition, but the prevalent rage of sun bathing, which has now lasted some years, has not been followed by development of hair on the backs of girls.

Chemicals

Greasy applications have been held responsible for stimulating the growth of hair on the face, but many girls 'cream' their faces at night and use a greasy preparation as a 'foundation' for their powder in the daytime, and yet hypertrichosis is not obviously on the increase. Mercuric chloride and sulphur have also been incriminated, but their general use in acne is not usually followed by hypertrichosis.

Summary

To sum up, it appears that with a natural tendency towards hypertrichosis any of these agencies—strong sunlight, damp heat, grease, mercuric salts, and sulphur—may activate it, but without this tendency their effect is either absent or fleeting.

*(b) Treatment**X-rays*

Six methods of treatment may be mentioned:

(i) X-rays. This method has been used to a greater extent in Europe and the United States than in Britain. By giving a full epilating dose of the rays and repeating this at intervals of not less than one month on four or five occasions the hair papillae may be permanently atrophied. Some have used smaller doses in larger numbers and at shorter intervals. It has been claimed that with careful management the hair follicles may be destroyed without other damage to the skin. This is not true, though the damage may not become obvious for two or more years after cessation of the treatment. After a variable period the whole skin undergoes atrophy associated with the development of telangiectases and in some cases pruritus. This method, therefore, cannot be too strongly condemned.

Shaving

(ii) Shaving. This method is harmless, but, the results being temporary only, it must be repeated daily when the growth of hair is strong. In addition to this the area shaved is very obvious if the hair is dark, as the intrafollicular portion shows through the skin. It is, however, a

mistake to believe that shaving increases either the coarseness or the rate of growth of the hair. This has been known empirically to be untrue for many years, but more recently experiments on localized portions of the hairy region have proved that the hair, when allowed to grow again, does not grow more rapidly and is not coarser in calibre.

(iii) Friction with pumice stone and soap. It has been stated that continued pumice-stoning weakens the hairs to final abolition; but this has not been so in the cases which have come within my experience. The skin of the hypertrichotic patient should indeed be left as free from stimulation as possible, constant grinding of the horny layer slightly increasing both the rate of growth and the coarseness of the hair. *Friction by pumice stone*

(iv) Depilatory powders and creams. These usually contain barium, strontium, or sodium sulphide and simply burn off the hair at skin level; in other words, they constitute a chemical shave. But, as they redden the skin, they stimulate growth in some degree. *Depilatory powders*

(v) Epilation by tweezers. When only a few hairs are present this method does little harm, and when a hair is pulled out there is an interval of about six weeks before the appearance of a new one. When there are many, the epilation must be repeated continually, and it is probable that individual hairs are replaced by coarser ones, though the method does not increase the numbers to an important degree. It has, however, the disadvantage that the frequently repeated evulsion is in some patients apt to set up chronic folliculitis. *Epilation by tweezers*

(vi) Epilation by the electrolytic and the diathermy needle. Of these two the former is probably much the more accurate. It is slightly slower and more painful, but the results in skilful hands are far better. Electrolytic destruction of the hair is an extremely delicate operation and, unless the operator is skilled, gives unsatisfactory results. The method is described under the title ELECTROTHERAPY, Vol. IV, p. 497. Its advantages are that it is safe, leaves negligible scarring, and in skilled hands gives permanent results; its disadvantages are that it is expensive, slow, and painful for the patient, and exacting and tiring for the operator. *Electrolysis and diathermy*

This procedure is said to stimulate the growth of fresh hair in the neighbourhood, but I have never seen this. *A priori* it would be expected to do so, for any irritant has that tendency; but small numbers of long hairs may be removed from the upper lip near the angles of the mouth, and the condition then sometimes remains stationary for years. Moreover it must be remembered that the condition is commonly progressive.

The suitability of a case for electrolysis bears a relation to the number of hairs requiring destruction. It therefore depends upon the amount of time and expense which the patient can afford and the amount of firm perseverance that the operator will devote. *Selection of cases for electrolysis*

At the first visit the patient should be informed that if she feels the extraction of the hairs the procedure has failed. This stimulates the operator to special care, for any mistake or slackness on his part becomes known at once to the patient.

(3)—Local Hypertrichosis associated with Moles

Only the common dome-shaped mole about a quarter of an inch in diameter will be dealt with here, as larger ones must be either removed by excision or left alone.

*Depilation
and
electrolysis*

The first question is: Is it justifiable to depilate a mole and destroy it by electrolysis? It has been said that to destroy a mole by electrolysis is to take an unjustifiable risk of converting it into a melanoma, but I do not hold this view. Dermatologists have been destroying small facial moles for many years, but I have never seen or read of a melanoma which started in a mole after electrolysis and therefore continue to depilate and destroy small moles by electrolysis, if this seems likely to give the best result.

Technique

The method of depilation is the same for hairs in moles as for hairs growing on normal skin, with two exceptions. The first is that because the follicles in moles are sometimes distorted and the mole tissue softer than normal skin, the depilation is more difficult; the second is that in order to destroy the mole at the same time a stronger current, up to five milliamperes, may be used. I destroy the mole after depilating the hair, at the same visit.

3.—TRICHOPTILOSIS

607.] Splitting and breaking of the hair usually occurs in long hair only. The exact cause is not known, but it is evidently due to faulty development of the hair shaft and is generally associated with pityriasis of the scalp (see SEBORRHOEA AND SEBORRHOEIC DERMATITIS).

Treatment



Treatment should in the first place be directed to the cure of the pityriasis capitis. The split hair should also be cut a little below the split in order to prevent its extension. Sometimes rubbing the hair with a small amount of sesame oil and then gently brushing it will prevent the splitting by softening the hair. Strongly alkaline soaps should be avoided.

4.—TRICHORRHEXIS NODOSA

608.] In this disease the cells of the cortex of the hair are loosened from one another locally, producing nodose swellings. At these nodes the hair is apt to break off, leaving a fringed end (see Fig. 14). When the nodes are present in large numbers, most of the hairs break, and few attain their normal length.

*Clinical
features*

FIG. 14.—Trichorrhexis nodosa. *a*, Node made up of two brushes; *b*, node with upper brush split into three; *c*, hair shaft. (This and Fig. 15 from *Pathology of the Skin* by J. M. H. MacLeod)

Many cases have been reported from the Near East in the hair of the scalp in women and have given rise to the suspicion of an epidemic infection. Menahem Hodara described a bacillus as the cause, but his findings have not been generally corroborated.

The condition is also found occasionally in the moustache hair of men. Erasmus Wilson ascribed the condition to injury of the hair, and later Sabouraud insisted upon this as a cause, pointing out that the condition could be found in the hair of shaving-brushes as the result of the repeated action of soap combined perhaps with bending of the hair. Lassueur supported this view and produced the condition experimentally in the moustaches of men who volunteered to wash repeatedly with various soaps. That there is an innate delicacy of the hair rendering it sensitive to injury was proved by Adamson, who found that if a hair from a normal person was laid upon a glass slide and struck smartly with the edge of a paper knife either it was fractured right across or it showed an ordinary green-stick fracture; whereas if an apparently sound hair from an affected person was so treated it developed the characteristic node.

*Aetiology**Sensitivity to injury*

The treatment is the same as that for trichoptilosis (see p. 166).

Treatment

5.—MONILITHRIX (BEADED HAIR)

609.] In this rare familial affection the hair shows constrictions of the shaft at almost equidistant intervals, and at these the medulla of the

Clinical features

FIG. 15.—Monilithrix: hair twisted and beaded

hair is usually absent. Owing to the thinning at these positions the hair breaks and therefore does not attain its full length. In severe cases the fractures may occur so close to the scalp that the appearance is that of a general alopecia, but usually some hairs about an inch in length remain.

The affection gives rise to a peculiar glittering appearance of the hair, and on examination with lenses the beaded formation is obvious at once (see Fig. 15). The condition is often associated with some hyperkeratosis of the mouths of the follicles, and the constrictions have been attributed to this. It is more probably due to a rhythmic diminution of the activity of the hair bulb, and Adamson in a personal communication pointed out that it could be imitated by giving repeated doses of X-rays, each just insufficient to cause fall of the hair. No treatment is known.

Pathogeny

6.—INGROWING HAIR

Clinical features

610.] This is a somewhat rare condition; I have seen it only in the beard region of men, where it causes much discomfort. The patient complains of 'pimples' at the mouths of the hair follicles, as there is generally some redness there. Some of the hairs run at an acute angle with the skin surface and do not emerge in the line of the follicle; they tunnel under the horny layer and in some instances fail to emerge at all but become wound up like a watch-spring and cause inflammation.

Pathogeny

The cause of this complaint is unknown; possibly the natural exit has been blocked by hyperkeratosis, though scaling is not obvious; or it may be due to the use of somewhat irritating soap and a blunt razor.

Treatment

The hair may be released by running a sterile needle under the horizontally lying shaft and hooking it free. If the patient ceases to shave for a time, the condition ceases to arise. Failing this, the following course may be advised: first, the use of a very sharp blade; secondly, a change to a shaving soap that is known to be free from irritating qualities; and thirdly, the use of salicylic acid 2 per cent in equal parts of alcohol and glycerin after shaving. This keeps the horny layer soft and apparently cures the condition.

7.—TEIGNE AMIANTACÉE (SHEATH PITYRIASIS)

Clinical features

611.] This rare disease, in my view identical with *fausse teigne* (see IMPETIGO), is better known in France than in England and, as it has not an English name, may be called sheath pityriasis.

Morbid anatomy

The disease affects the scalp of children in patches of various sizes. At first sight it is liable to be regarded as microsporon ringworm, because the patch seems to be covered with whitish stumps. On close examination, however, these whitish cylinders are seen to be not 'stumps' but projections of horny tissue about one-eighth of an inch long with unbroken hairs running through them. In addition there are flat scales lying on the skin between the hairs. Occasionally the scaling is so abundant that the patch looks as if melted wax had been dropped over the area and had solidified on the skin and around the hairs.

Histology and bacteriology

Dubreuilh showed that microscopically the sheath consisted of a chain of horny cones in close apposition and derived from the mouth of the follicle. Various micro-organisms have been incriminated, but skilled observers have failed to find any organisms in the horny growths and have found them sterile on cultivation.

Ætiology

The cause is unknown. It is important to distinguish the disease from microsporon ringworm—which is easy, and also from underlying endothrix infection—which needs careful investigation. The condition is apparently not contagious.

Treatment

Treatment with strong ointment of mercuric nitrate 10 per cent,

diluted with soft paraffin, causes rapid disappearance of the desquamation and, if persistently used for a long period, cures the condition.

8.—TRICHOMYCOSIS

612.] This, which is a growth of micro-organisms on the extrafollicular portion of the hair shaft may be divided into: (1) *Lepothrix*, comprising *Varieties* trichomycosis palmellina and trichomycosis nodosa; (2) piedra, comprising Columbian piedra, Ceylon piedra, and piedra nostras.

(1)—*Lepothrix*

The two forms of this disease are similar and may be identical. It *Clinical features* involves the hair of various parts of the body, more commonly the axilla, and appears as an irregular sheath of organisms surrounding the hair, which therefore appears ragged and is easily broken. The accretion varies in colour from yellow to nearly black.

The mycology is still somewhat doubtful, but large coccoid forms and *Mycology* mycelial elements have been described. In some cases the sweat is coloured red, and it has been suggested that *Micrococcus tetragenus* is also present.

(2)—*Piedra*

This disease differs from the preceding in the fact that the accretion forms minute stony hard nodules on the hair rather than a complete sheath. It is described under the title FUNGOUS DISEASES, Vol. V, p. 472.

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HALLUX FLEXUS AND HALLUX RIGIDUS

See FOOT, DISEASES AND DEFORMITIES, Vol. V, p. 422

HALLUX VALGUS

See CORNS AND BUNIONS, Vol. III, p. 435; *and* FOOT,
DISEASES AND DEFORMITIES, Vol. V, p. 420

HAMMER-TOE

See FOOT, DISEASES AND DEFORMITIES, Vol. V, p. 423

HAND, DISEASES AND DEFORMITIES

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Reference may also be made to the following titles:

ACHONDROPLASIA	DUPUYTREN'S
ACROMEGALY	CONTRACTION
ACROPARAESTHESIA	EPIPHYSES, DISEASES AND
BONE DISEASES	INJURIES
CERVICAL RIB	FOETUS DISEASES
DISLOCATIONS AND	JOINTS, DISEASES AND
FRACTURES	DISORDERS
RAYNAUD'S DISEASE	

1.—DEFORMITIES

(1)—Congenital

613.] The establishment of both fore and hind limbs as three-sectioned (i.e. arm, forearm, and hand) pentadactyl structures occurred so early in evolutionary history that it cannot be expected that variations from the standard would be at all common. Indeed gross congenital defects in the development of the hand are rare, but minor deformities occur sufficiently often to merit attention.

Polydactyly

Polydactyly has a familial incidence and has been described as affecting whole tribes; it is sometimes associated with a similar condition in the feet (see Vol. V, p. 414). The addition of a digit, or digits, is usually on the inner or outer border of the hand and varies in size from a mere pedunculated nodule to a complete functioning digit. Occasionally the condition is combined with syndactyly, the extra digit being more or less completely fused with one of the others.

A small non-functioning digit should be removed shortly after birth, but a complete functioning extra digit should probably be left alone, since the only reason for its removal would be a cosmetic one, and many patients who have reached adult life with such a deformity regard it as an asset rather than a disability.

Even in the less common uni-

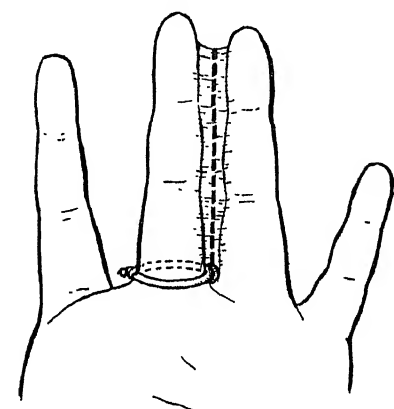


FIG. 16.—Operation for syndactyly when the web consists of a thin membrane. The silver ring is first inserted through a hole at the base of the web, and subsequently, when this aperture is epithelialized, the web is divided as shown

lateral cases this decision is not influenced, as it is in the case of the foot, by the necessity of providing special coverings.

Syndactyly

Syndactyly varies in degree from the mere presence of a thin web extending lower than normal to the complete fusion of two digits, including even the bones and nails. For both utilitarian and cosmetic reasons operative treatment is necessary in most cases. When a thin web is present simple division is all that is necessary, but to avoid the re-development of a fibrous union between the digits an effort should be made to get the proximal end of the web completely healed and epithelialized before the rest is divided. This may be accomplished by the classical method of passing a stout silver wire through a hole in the proximal web and waiting until the sinus so produced has healed. The main portion of the web may now be divided, and the fingers kept separated by dressings until the linear scars have closed (see Fig. 16).

Division of web

In cases in which the union is thick, but does not involve the bones,

longitudinal skin flaps are raised from the palmar aspect of one digit and the dorsal aspect of its neighbour, facing in opposite directions; the fingers are then separated and the skin flaps wrapped round their corresponding digits (see Fig. 17). Even so, there is usually not enough skin to cover the raw areas completely, and resort must be had to skin grafting.

When the bones are united they may be divided, but before embarking upon this rather unsatisfactory procedure the surgeon should be satisfied that it is justified by the disability present. In many of these cases the ultimate result is the sacrifice of one or other half of the combined digit. In extreme cases therefore it is advisable to aim for this from the start, since it is thus possible to retain a sufficiency of skin to cover the reduced digit.

In macrodactyly there may be tremendous hypertrophy of one digit; the soft tissues are chiefly concerned, although occasionally the bones also are involved, or the large digit may in reality be the fusion of two or three, representing an extreme syndactyly. For utilitarian and cosmetic reasons a large digit should usually be reduced in size, a fairly easy operation if the soft tissues form the main bulk of the enlargement.

Absence of digits due to maldevelopment or amputation in utero is much rarer than the conditions just described and obviously does not lend itself to any treatment.

A completely cleft hand, corresponding to a lobster-claw deformity of the foot, with which it may be associated, is very rare but is compatible with a fair degree of manipulative ability.

A contracture of the little finger is often associated with a corresponding, although less noticeable, contracture of the fifth toe; the condition is familial in incidence and differs from a Dupuytren's contracture in that the palmar fascia is not fibrotic nor will its removal allow of straightening of the fingers, since all the flexor structures are involved,

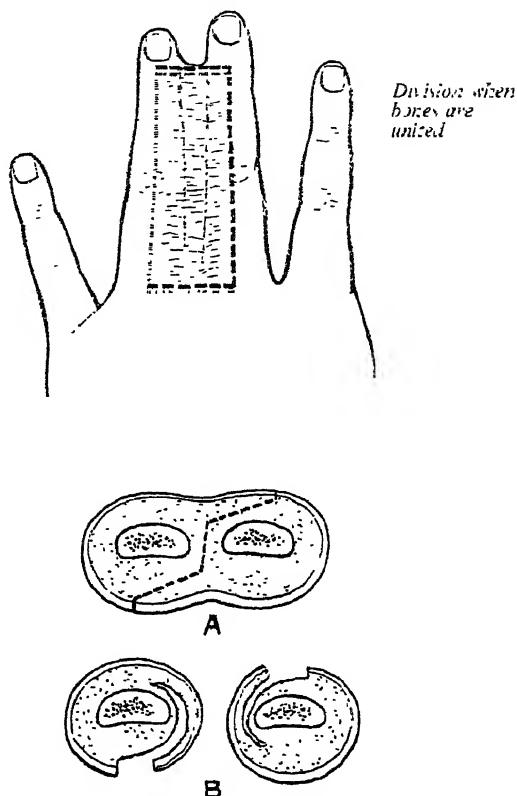


FIG. 17.—Operation for syndactyly when the union consists of a thick layer of tissue. A, Flaps formed from the palmar aspect of one digit and the dorsal aspect of the other. B, Flaps applied over the raw areas after separation of the digits

Absence of digits

Cleft hand

Contracture of little finger

tendons, ligaments, and joints. If recognized at an early period, much can be done to correct the deformity by the use of manipulative methods and splints. Usually the extent of the contracture is slight and causes but little disability.

Madelung's deformity

In 1897, when Madelung wrote his paper on the deformity which bears his name, radiography had not yet come into general use (X-rays had only been discovered in 1895), and so the diagnosis of the condition rested on a clinical rather than on a pathological basis. The causes are probably multiple, and the relation to trauma is disputed; but, however the condition is produced, the result is a defect in the ossification of the

Treatment

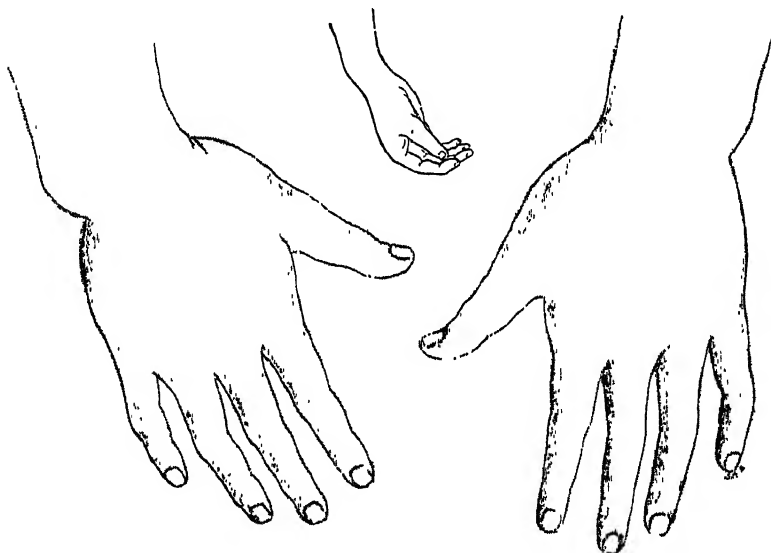


FIG. 18.—Madelung's deformity of the wrist. Note the radial and forward deviation of the wrist and hand, and the prominence on the inner side produced by the lower end of the ulna

lower radial epiphysis, with radial and forward displacement of the hand and prominence of the lower end of the ulna on the inner side (see Fig. 18). As there is a definite lack of bone formation at the lower end of the radius, the only way to correct the deformity is to stop the growth of the lower end of the ulna by the removal of the epiphysal plate; the piece so removed may be used as a corrective wedge in the linear osteotomy of the radius which is done at the same time.

Achondroplasia

Deformities of the hand also occur in generalized conditions affecting the growth of bones; thus in achondroplasia there is a deficient growth in the length of the cartilage bones, including the metacarpals and phalanges. As increase of girth is less interfered with, the metacarpals are forced into the divergent position giving the so-called 'trident' hand (see Vol. I, Fig. 30, p. 139). In acromegaly the hand enlarges in conjunction with the foot and other parts of the skeleton; the hypertrophy

Acromegaly

involves all the structures, and so no deformity results. In *fragilitas ossium* (osteopsathyrosis) there is hyperextension of all the fingers and especially of the thumb, owing to the laxity of the mesoblastic structures. *Fragilitas ossium*

The term club-hand may be applied to any deformity in which the hand has a clubbed or lumpy appearance, but is commonly confined to congenital cases of partial or total absence of bones in the forearm; thus absence of the radius produces a radial club-hand, the commonest type. Ulnar, dorsal and palmar club-hands are also described, associated with absence of the ulna or of the wrist bones respectively. *Club-hand*

(2)—Acquired

The acquired deformities of the hand are numerous. They are due to local injury or disease of various structures: e.g. the skin and subcutaneous tissues in burns; the tendons, as in trigger finger; the nerves, as in ulnar palsy; the muscles, as in Volkmann's contracture; or the palmar fascia, as in Dupuytren's contracture. In addition the fingers may show local manifestations of general disease: e.g. clubbed fingers, pulmonary osteoarthropathy.

The treatment of burns is dealt with elsewhere (see BURNS AND SCALDS, *Burns* Vol. II. p. 723). The resulting deformities in the hand are due to the fibrotic contraction of the scar, and are particularly disabling when a deep burn of the palm leads to contraction of the whole of the palmar fascia; fortunately this dense layer usually protects the underlying nerves, vessels, and tendons. The only treatment for these deformities is excision of all the scar tissue and the application of a whole thickness skin graft. This may be accomplished by slipping the hand, dissected quite free of the scar, under a bridge of skin and fat raised in the loin. When the graft has 'taken', i.e. after three or four weeks, the hand is freed again and subsequent small operations are undertaken, for example to form new webs to the fingers.

The division of tendons in the wound is followed by their immediate or delayed suture, which, if successful, prevents the development of permanent deformities. When suture is not done, or is unsuccessful, the resultant deformity is the combined effect of disturbance of muscle balance and of the restrictions caused by adhesions. Suture of the flexor tendons where they run in sheaths is by no means uniformly successful, for dense adhesion of tendon to sheath is prone to follow with a result no better than would have been obtained had the tendon remained unsutured; but this does not apply with the same force in completely aseptic cases. *Division of tendons*

Rupture of the extensor aponeurosis to the fingers may occur subcutaneously as a result of forced sudden flexion of the terminal joint. This produces a palmar flexion of the terminal phalanx, 'mallet finger'. In many instances the rupture is incomplete and the application of a small splint to hold the finger hyperextended for three or four weeks will give a good result. If this fails, the tendon may be sutured back to the bone by open operation. Owing to the prolonged immobility necessary *Rupture of extensor aponeurosis*

to ensure union some degree of permanent stiffness of the joint is very likely to follow.

Ulnar palsy The most characteristic deformity associated with the division of nerves is an ulnar palsy, which varies according to the level at which the nerve is interrupted and to the completeness of that interruption. If the nerve is divided at the level of the wrist there is paralysis of the intrinsic muscles of the hand, except the flexor brevis, abductor and opponens pollicis, and the outer two lumbricals, which are supplied by the median nerve. There is thus wasting of the hypothenar eminence and of the interossei, and the little and ring fingers are slightly 'clawed', i.e. hyperextended at the metacarpophalangeal and flexed at the interphalangeal joints; if the sensory branch is involved, there is a sensory loss over the ulnar border of the hand and the inner one and a half fingers. When the injury is above the level of the elbow, the effects of paralysis of the long muscles on the inner aspect of the forearm are added to this. There is more extensive clawing on the ulnar side.

Claw hand The typical *main en griffe*, however, is seen only when there is an associated lesion of the median nerve, or when the lower trunk of the brachial plexus is injured, since it supplies fibres to both nerves. There is now complete clawing of all the fingers, wasting of both thenar and hypothenar eminences, and hyperextension of the wrist. A mild degree of this deformity occurs in cases of cervical rib, and is produced by the stretching of the lower brachial trunk over the rib. Since this trunk carries the vasomotor supply to the upper limb, vascular phenomena simulating Raynaud's disease are often associated.

Complete paralysis: 'ape-hand' In complete paralysis of all the muscles of the hand, as in progressive muscular atrophy and syringomyelia, the flattened hand, with loss of the palmar arch, slight extension of the knuckles, and flexion of the other joints, gives an appearance appropriately described as 'ape hand'.

Wrist-drop Wrist-drop is a further example of a deformity due to interference with the nerve-supply. It consists of a paralysis of the extensor muscles supplied by the dorsal interosseous nerve, a branch of the radial. A toxic neuritis of this nerve is associated with poisoning by the heavy metals, particularly lead, but a traumatic neuritis may arise from the pressure of a crutch or the edge of the table during operations. The wrist-drop of a 'Saturday night palsy', now seen but rarely, arises in a similar way, by pressure upon the radial nerve.

Volkmann's contracture Deformities due to muscular contracture are best exemplified in Volkmann's contracture, in which, as a result of a fibrosing myositis, the flexor muscles of the forearm are shortened beyond the possibilities of adaptation, and so the fingers become flexed into the palm. If the wrist is flexed, however, some degree of both active and passive extension becomes possible, thus indicating the true nature of the condition (see Fig. 19). In most cases there are not any associated sensory changes.

Causes The condition commonly arises as a sequel to the application of tight splints for fractures in the forearm, or the adoption of the Jones's

flexion position for fractures about the elbow-joint, and for these reasons is usually seen in young patients. Suppurative lesions of the flexor muscles, when followed by fibrosis, may produce a similar deformity. The contracture has been variously ascribed to a fibrosing myositis following trauma, to ischaemia due to the direct pressure of splints in the presence of swelling, and to an ischaemia of secondary origin due to interference with the vasomotor fibres supplying the muscles as the somatic nerves pass in front of the elbow-joint. The condition, however produced, leads to a very crippling deformity.

The best treatment is undoubtedly prophylactic; the greatest of care must be taken in the application of any splints to the forearm, and patients must be kept under close observation for several days subsequently. Skin-tight plasters should never be used here so long as there is any possibility that further swelling will occur. The flexion method of treatment for elbow fractures is not as popular as it was formerly; if it is used at all, it should be limited to those cases in which it is possible to keep the patient under the closest observation every few hours.

When the deformity has

occurred, its severity and duration determine the treatment. In recent mild cases the muscles may be stretched by the application of a splint which, being applied in the deformed position, can be slowly extended mechanically; this treatment is continued for several months.

For more severe cases operative treatment is essential; the object is to obtain relative lengthening of the flexor muscles. Multiple tendon-lengthening has been largely abandoned on account of its difficulties

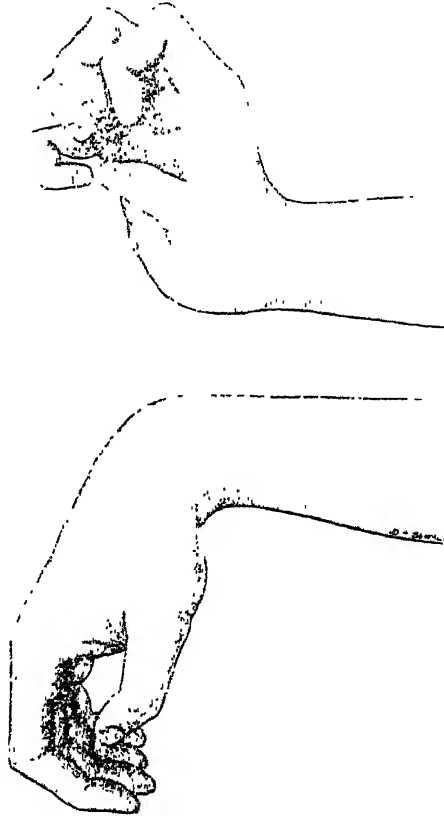


FIG. 19.—The deformity of the hand in a moderate degree of Volkmann's contracture. Note that when the wrist is fully flexed the fingers can be partially extended, but with the wrist dorsiflexed the fingers are drawn into the palm by the shortened flexor muscles

and bad results. Shortening of both bones of the forearm has given good results, but it of necessity weakens the extensor muscles; this result, however, is not always a disadvantage, since it helps to restore the muscle balance. The most popular operation at the present day is that in which the origin of the flexor muscles is detached from the internal epicondyle of the humerus and allowed to slide down into the forearm, there to gain a fresh origin. On the whole I have had better results from the bone-shortening operation and have in some cases performed this with advantage when the muscle-sliding operation has proved disappointing.

Dupuytren's contraction

Idiopathic fibrosis of the palmar fascia causes a characteristic deformity of the fingers named after Dupuytren; it is dealt with under the title DUPUYTREN'S CONTRACTION, Vol. IV, p. 272.

Fibrous nodule in flexor tendon

The development of a fibrous nodule in a flexor tendon, as it passes in its sheath, produces a mechanical hitch to extension of the finger as the nodule gets jammed in the narrow portions of the osseo-aponeurotic canal in which the tendon runs. Towards the end of extension, or when helped by a slight push, the nodule escapes from the obstruction, and the finger suddenly snaps into the extended position; this is known as 'trigger finger'. The origin of the fibrous nodule is in doubt, but in many instances there is a previous history of trauma suggesting a rupture of some of the tendinous fibres, which is followed by fibrosis. Such nodules are sometimes easily palpable, and their localization in this way is important before surgical treatment is undertaken.

Trigger finger

Treatment

In a few cases the condition remedies itself in time, probably by enlargement of the sheath or elongation of the nodule. In other cases operation is necessary; the sheath is divided and, if the nodule is conspicuous, it is dissected off the tendon; otherwise the division of the sheath is sufficient.

Clubbing and pulmonary osteoarthropathy

The relationship between clubbing of the fingers (first described by Hippocrates) and hypertrophic pulmonary osteoarthropathy (described by Marie in 1890) is still little understood. Some believe that the former is but an earlier stage of the latter; others consider that they are of separate aetiology. Both are associated with intrathoracic conditions, especially those producing cyanosis and dyspnoea, such as congenital heart disease, right-sided heart failure, tuberculosis, new growths, and suppurative lesions. The former are more likely to be associated with simple clubbing, and the latter, in which there is a toxic element, with an osteoarthropathy.

In clubbing the soft parts of the terminal phalanges are thickened and bulbous, and the nails curved longitudinally and transversely; in arthropathy the tips of the fingers may not be affected first, but there is a proliferative change in the bones of the phalanges and arthritic changes in the joints with osteophytic outgrowths; the condition extends to the long bones of the forearm and even to the root of the limb and the spine. These bony changes are well shown by radiography. Occasionally they may be the first indications of some pulmonary diseases. The importance of the condition lies in its value as an indicator of intrathoracic disease or

very occasionally of some other source of toxæmia. The prognosis is obviously bad, but in the cases associated with toxic conditions, e.g. bronchiectasis, empyema, and lung abscess, clubbing may almost vanish after the eradication of the primary disease.

2.—INJURIES

(1)—Causes and Types of Injury

614.] Injuries to the hand constitute one of the most important sections of traumatic surgery owing to the immense economic value of the hand to the individual. There are few occupations in which the hand is not essential, owing to its prehensile powers and its delicate control, but for this reason it is very often exposed to the danger of injury. Many of these injuries are of industrial origin, and, were it not for the efficiency of the reflex protective mechanisms, such as rapid withdrawal, damage would be sustained in a much larger percentage of potential instances. The same factors too determine the type of injury, so that a comparison of the hand with the foot shows that cuts, penetrating wounds, partial amputation of digits, and avulsion are common in the hand, whereas crushes, lacerated wounds, and fractures are common in the foot. The increasing mechanization of industry has not led to any great increase in these injuries, for there have been developed *pari passu* safety mechanisms to protect the worker; these consist not only of adequate guards for moving parts but of ingenious means of stopping the machine if the worker makes an unusual or dangerous move. Specialized training for specific work also has a definite protective influence. This is well shown in the report of the Chief Inspector of Factories for 1936, for, although in proportion to the numbers employed there has been a steady fall in accidents, especially fatal ones, since 1924, it is noted that 'the immediate effect of increased employment is to cause a more than proportionate increase of accidents, owing to the engagement of inexperienced young workers and of unemployed older workers who have lost some of their skill' (see also INDUSTRIAL ACCIDENTS). *Industrial injuries*

Injuries to the hands may be roughly divided into the following categories: penetrating wounds, caused by needles and other sharp tools or splinters of wood or metal; incised wounds and cuts, produced by cutting tools, such as knives and chisels, or by glass; lacerated wounds of irregular shape and with usually a good deal of surrounding contusion, produced in various ways, e.g. by geared machinery; bruises and crushes, produced by jamming between two moving parts, e.g. stamping machines; fractures occurring as the main injury or, often, as a complication of one of the others; involuntary amputations, produced by guillotines, shearing machines, and circular saws; and finally avulsion of one or more digits when caught in revolving machinery, such as a printing press. *Classification*

Burns and scalds form a separate group of injuries, the cause being thermal, chemical, electrical, or radiant.

(2)—Complications*Infection*

The prognosis of any injury is tremendously affected by the presence of added infection, which constitutes the most important of all the complications. As infection, however, is by no means always post-traumatic it will be dealt with in a separate section (see p. 182), but here, before passing to a consideration of the purely mechanical aspects, it is necessary to emphasize the warning there given against attempts at immediate closure of incised and lacerated wounds. It is true that many injuries are caused by materials which are not in themselves likely to carry a virulent infection; indeed in some cases the material is sterile, e.g. hot turnings or splinters from a lathe or milling machine. Nevertheless the wound is often contused and therefore lined by devitalized tissues which are very prone to infection; such infection may be derived from the patient's skin, if it is not healthy, or even from parts as remote as the teeth or tonsils. Only in exceptional circumstances can it be necessary to close the wound at once. The patient's rather natural desire to see the *status quo ante* restored should be stoutly resisted.

Division of nerves and tendons

As complications of many of these injuries there may also be division of tendons, nerves, or vessels, and in all incised or lacerated wounds a very careful examination must be made for possible division of tendons and nerves, and care must be exercised not to mistake one for the other. Inability to perform certain movements may be due either to involvement of the nerve-supply to a muscle or to division of its tendon; sometimes the injuries co-exist. Owing to the elasticity of the skin a small superficial wound may be associated with extensive damage to deeper structures, a circumstance which may mislead the unwary. Divided tendons and nerves must be sutured, but not of necessity immediately. In the presence of much damaged tissue or the probability of infection, despite thorough cleansing of the wound, it is better to identify the various divided structures and to prevent their retraction by the passage of loose sutures (they may be individually coloured) through them, the wound being then lightly packed with gauze soaked in flavine in watery solution 1 in 1,000. After a day or two, when it is obvious that no gross infection is present, a secondary suture can be undertaken. When many tendons in close proximity are divided, i.e. at the wrist, difficulty may arise in deciding which to join to which; but a knowledge of the anatomy of the part, combined with a test of the distal ends by pulling upon each in turn and noting the movement which occurs, will usually enable them to be correctly sorted out.

*Treatment**Haemorrhage*

Bleeding as a complication of injuries to the palm may be difficult to control. Owing to the close proximity of many important structures under the palmar fascia, the blind application of artery forceps is not advised; nevertheless bleeding here should be treated by local haemostasis and not by ligature of the proximal vessels, i.e. the radial and ulnar, except in the last resort. This means that, until the wound can

be properly explored under anaesthesia, the bleeding must be controlled either by local pressure or the application of a tourniquet. The latter can be used only for very short periods of time if ischaemic damage is to be avoided. When the wound has been cleaned and opened, it becomes possible to recognize important structures and to avoid them: a ligature is then placed on the vessel, which is usually the deep palmar arch.

Fractures are dealt with in the article on DISLOCATIONS AND FRACTURES, Vol. IV, p. 149.

(3)—Removal of Foreign Body

A special case arises when some foreign material is left in the wound after injury. Since this consists of a portion of the object causing the wound, it is frequently metallic, but it may be wood, glass, or other material. The presence of a foreign body is quite commonly made clear by radiography: metals give good shadows; glass, especially if of the cheaper varieties, earthenware, and china usually give a recognizable shadow; but wood is less certain unless the particle is of considerable size, though fortunately some adherent paint or other radio-opaque covering is often present in sufficient quantity to be recognized. Accuracy of localization is essential before any attempt at removal is undertaken; radiographs in two planes at right angles are useful, as also are stereoscopic views. It is, however, often advisable to conduct the operation under the guidance of screening, after the preliminary stages of approach have brought the operator to the vicinity of the object. It must be stated emphatically that a sterile foreign body, especially if metallic, need not be removed unless it is so placed as to cause symptoms. Many fruitless operations resulting in great disability have been performed for the removal of metallic splinters or needle points embedded in bone or other inert structures where they would not have caused any trouble if left.

All operations for the removal of foreign bodies, except when merely subcuticular, must be conducted under full anaesthesia in a properly equipped operating theatre with X-ray facilities. There should not be any hurry at any stage, and the line of approach should be placed so as to avoid important anatomical structures. A needle should be approached transversely to its long axis whenever the anatomical relations allow. The strictest aseptic precautions must be maintained throughout the operation, since it may necessitate the opening up of many fascial planes and lymphatic spaces.

A remote effect of the penetration of the skin of the palm and flexor aspect of the fingers is the production of an implantation cyst, containing sebaceous debris and lined with stratified epithelium. The chief interest of these cysts lies in their differentiation from other conditions. They are rarely larger than a pea, cannot be transilluminated, but give an imperfect fluctuation. Treatment is by removal under local anaesthesia.

3.—INFECTIONS

(1)—Anatomical Features

615.] The diagnosis and treatment of infections of the hand and fingers depend so intimately upon a knowledge of the anatomy of the parts that a review of the main anatomical features is an essential preliminary to any consideration of the subject.

*Tissues in
palmar aspect
of fingers*

The skin of the palmar aspect of the fingers is very tough, and in the vicinity of the joints it is held down to the digital extensions of the

palmar fascia to form characteristic creases. In the subcutaneous tissues the fat is divided into a large number of small loculi by fibrous septa passing from the deeper structures to the skin. This arrangement clearly prevents excessive movement of the skin during prehension; otherwise the facility with which objects are held firmly would be considerably diminished. The division of the fat into loculi is particularly well marked in the pulp of the terminal phalanx (see Fig. 20). Here the amount of fat is greater than elsewhere, and the loculi are disposed with their long axes at right angles to the surface. The pulp is thus divided into a

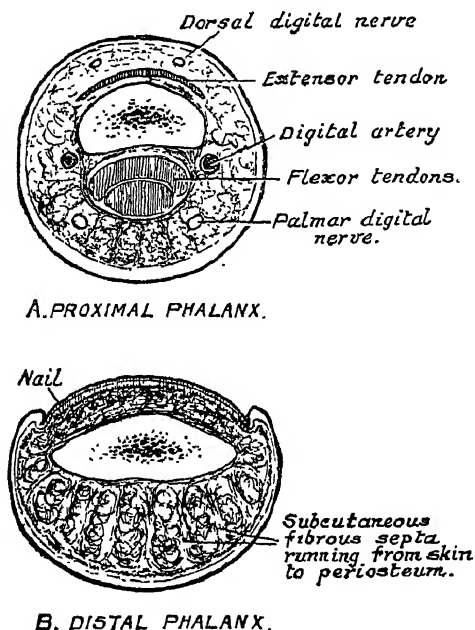


FIG. 20.—Transverse sections of finger to show relations of tendon-sheaths, nerves, and blood-vessels. Note loculation of fat over palmar aspect, especially in terminal pulp. (This and Figs. 21 and 23 from *Surgical Anatomy and Physiology* by Lake and Marshall)

large number of spaces arranged rather like the cells in a honeycomb. In the presence of infection inflammatory exudations are therefore unable to spread widely, as they can elsewhere, but are retained in the loculi, producing an extreme degree of tension, which often is sufficient to interfere with the blood-supply.

Dorsal aspect On the dorsal aspect of the fingers and hand there is much less subcutaneous tissue, but it is of an areolar type and permits very considerable exudation and swelling. The skin on this aspect is loose and elastic to allow of flexion, and for the same reason transverse creases occur

opposite the joints. The bed of the nail is firmly fixed to the underlying periosteum: the nail itself thus affords good counter-pressure to forces applied to the finger-tips. Only the slightest amount of to-and-fro

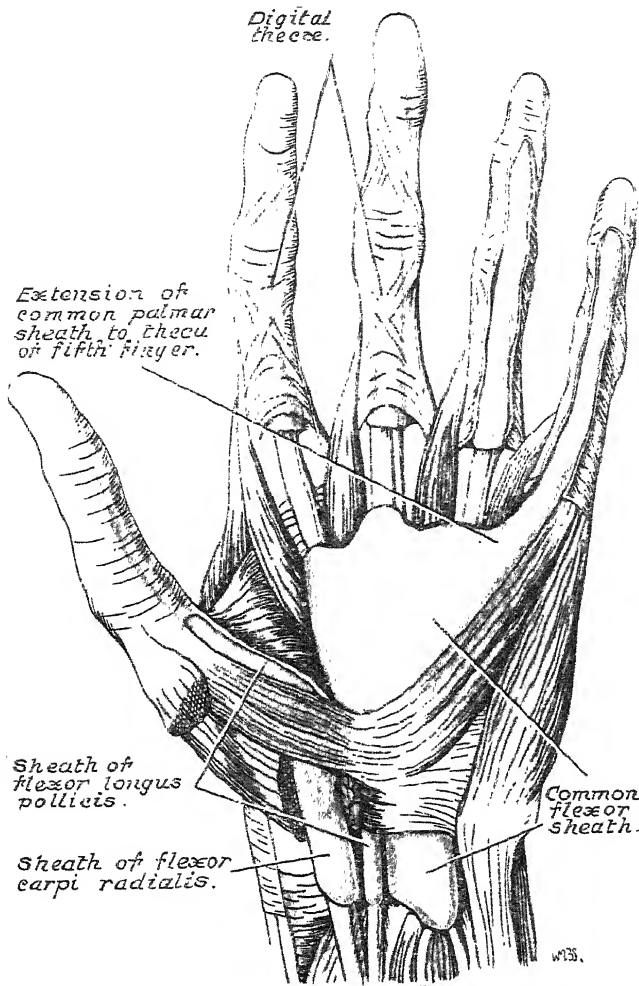


FIG. 21.—Relations of synovial sheaths of hand and fingers

movement of the nails can be detected normally; the range may be increased and the movement may be painful in affections underlying the nail, in its bed or in the bone.

On the palmar aspect of the fingers the tendons have well marked synovial sheaths, which extend from the base of the terminal phalanx to the distal skin crease of the palm (see Fig. 21). In the case of the little

*Tendons and
tendon-
sheaths*

finger the theca extends up through the palm and becomes continuous with the main palmar bursa (common flexor sheath) at the wrist. The thumb tendon has a sheath of its own, running from the base of the terminal phalanx up under the transverse carpal (anterior annular) ligament of the wrist.

All the digital synovial sheaths are contained within osseo-aponeurotic canals formed on the deep aspect by the periosteum of the phalanges, over the joints by their volar (glenoid) ligaments, and on the palmar and lateral aspects by a transversely-fibred arch with which the digital extension of the palmar fascia is blended. These sheaths are especially thickened, and their calibre is reduced, where they lie over the proximal and intermediate phalanges, but opposite the joints they are thinner and more lax. Even when the sheath is distended by inflammatory exudations, the tendon still fits fairly tightly at these restricted points, and it is here that localizing adhesions may form to limit the spread of the infection.

The special arrangement of the tendons by which the superficial one splits to permit the passage of the deep one obviously does not allow of the persistence of a complete mesotendon running the whole length of the sheath, such as occurs initially during development. Most of the mesotendon subsequently disappears, but the remains can be recognized as the vincula tendinum. These are, however, ineffective in providing an adequate blood-supply to the tendons, the nutrition of which is precarious, since they depend upon small vessels passing along the tendon from the palm, and an insignificant supply from the periosteum at their insertion. A slight increase in the tension within the theca is sufficient to cut off their blood-supply entirely, so that, although such passive structures as tendons require very little in the way of nutrition in normal circumstances, necrosis is very prone to occur in the presence of infection.

*Fascial
spaces of the
palm*

Kanavel, in his classic work on *Infections of the Hand*, has described the routes by which infection spreads in the hand. He was the first to indicate the importance of the palmar fascial spaces and to point out rational methods of surgical drainage. There is no need to emphasize the intimate attachments of the skin to the palmar fascia; only the thinnest layer of fibro-fatty tissue intervenes, and so loculated is this that infection in the superficial layers is unable to spread beyond a short distance before the skin is perforated and spontaneous drainage stops further extension. On the dorsal aspect of the hand there are two loose areolar spaces, one between the extensor aponeurosis and the skin (the dorsal subcutaneous space), and one between the aponeurosis and the bones (the dorsal subaponeurotic space). These are the spaces in which oedema is chiefly seen in infections involving the palmar spaces, the density of the palmar fascia preventing anything more than an undue fullness of the 'cup' of the palm.

*Dorsal
subcutaneous
and sub-
aponeurotic
spaces*

Under the palmar fascia the areolar intervals are divided into two main sections by the fascia over the adductor pollicis transversus muscle

(see Fig. 22). The palmar (mid-palmar) space is an extensive and important area, lying deep to the flexor digitorum profundus tendons and anterior to the third, fourth, and fifth metacarpal bones and the corresponding interossei. It is bounded on the inner and outer sides by partitions passing from the deep aspect of the palmar fascia to the third and fifth metacarpals respectively; the former is strong and separates this space from the thenar space. Proximally the palmar space extends by a narrow passage to the deep space of the forearm, and distally it is continuous with the web spaces and, by prolongations along the lumbricals, with the dorsal subaponeurotic space.

Mid-palmar space

The thenar space lies between the palmar fascia and the adductor, extending around the distal border of that muscle on to its dorsal aspect (see Fig. 23). It is separated from the palmar space by the fascia

Thenar space

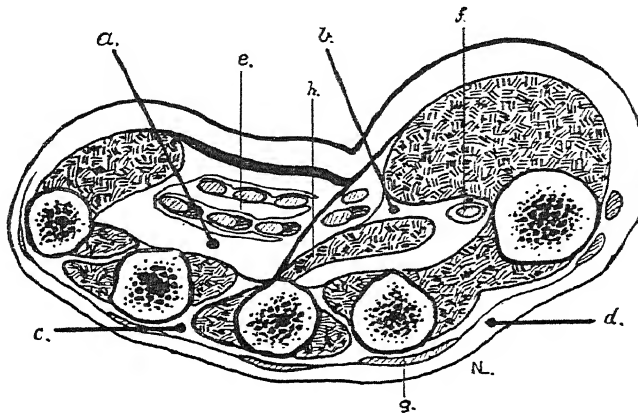


FIG. 22.—Transverse section of palm to show relations of palmar and thenar spaces; *a*, palmar space; *b*, thenar space; *c*, subaponeurotic dorsal space; *d*, subcutaneous dorsal space; *e*, palmar bursa (common flexor sheath); *f*, tendon of flexor longus pollicis; *g*, extensor tendons and aponeurosis; *h*, adductor pollicis transversus muscle. (This and Fig. 24 from *The Practitioner*)

already mentioned, which corresponds superficially with the skin crease running along the inner aspect of the thenar eminence. Externally it extends under the thumb muscles to the first metacarpal, and distally it communicates with the web spaces of the index and thumb and, via the first lumbrical canal, with the dorsum of the hand. It has no extension to the deep spaces of the forearm.

The web spaces lie between the heads of the metacarpals and are continuations of the mid-palmar and thenar spaces to the dorsal aspect of the bases of the fingers, there communicating with the subcutaneous spaces of the dorsum of the hand.

Web spaces

The deep fascial space of the forearm lies under the flexor digitorum profundus tendons and in front of the pronator quadratus muscle.

Deep fascial space of forearm

The interphalangeal and metacarpophalangeal joints are all in fairly intimate relation with the tendon-sheaths, and it has already been

Bones and joints

mentioned that their volar (glenoid) ligaments form part of the thecal canal. The phalanges have, before the age of about twenty, an epiphysis at their proximal ends, and the same applies to the first metacarpal. The other metacarpals have an epiphysis at the head. The blood-supply to that part of the bone derived from the epiphysis reaches it largely along the capsule of the joint, from the section of the digit immediately proximal. This is important in the case of the terminal phalanx, for, when the pressure of exudation in the terminal segment cuts off the main blood-supply to the bone, its base is still able to derive a supply

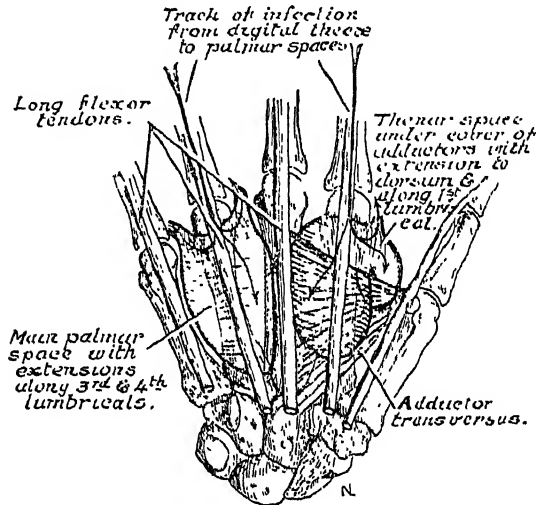


FIG. 23.—Diagram showing Kanavel's palmar spaces and routes by which infection reaches them from fingers

in this way, and so bony necrosis rarely extends to the base, and infections do not usually involve the interphalangeal joint.

Main palmar bursa

The main palmar bursa (common flexor sheath) is restricted as it passes deep to the transverse carpal (anterior annular) ligament, and extends up into the forearm for two finger-breadths proximal to the wrist crease (see Fig. 21). It is more extensive on the ulnar side and, as already mentioned, is continuous with the theca of the little finger.

Thumb sheath

The thumb sheath passes proximally, to about the same level; it is buried deeply as it passes beneath the muscles of the thenar eminence, and is crossed in this situation by the branch from the median nerve supplying those muscles. The vascular and nervous supplies to the radial side of the index finger cross the proximal end of the theca of that finger deep to the palmar crease in this situation (see also p. 192).

(2)—Aetiology

Wounds

Infection may reach the fingers and hand in many ways. The most obvious and important is by penetrating wounds, especially by needle

and pin pricks. These implant the organisms at the end of a long thin track, through which the natural flushing of protective serum is impossible. It would appear that many organisms are mechanically removed from the penetrating body as it forces its way through the dense skin on the volar aspect; otherwise infection would be even more frequent.

Infections arising from superficial lesions of the skin are also common, *Superficial skin lesions* in particular a 'hang-nail' is the portal of entry. Extensive lacerated and incised wounds are perhaps more prone to the development of infection here than in other parts of the body. This is probably because many of the divided structures retract well away from the cut, and so carry organisms into recesses of the wound which are neither flushed by the natural transudation of lymph nor easily reached by such antiseptics as may be used.

In some cases there is doubt whether or not infection of the fingers *Blood-borne infection* and hand is haematogenous, since a minute portal of entry may be easily overlooked. There are, however, exceptional cases in which it appears beyond doubt that the infection reaches the part from some other focus by way of the blood-stream. In all cases of apparently spontaneous infection the suspicion of an underlying constitutional condition, such as diabetes mellitus, must arise, and this suspicion must be confuted or confirmed before surgical measures are instituted. Infection of one part may arise by spread from another; thus infections of the palmar spaces frequently follow infection of a finger. In many instances this spread is continuous, the infection extending along the fascial spaces or in the thecal sheaths, the latter subsequently bursting at their proximal ends into the cellular tissues of the palm. In other cases, however, the spread is discontinuous; the organisms, travelling along lymphatic spaces or vessels, are arrested in the palm and there set up a new zone of infection. Distal spread is also common; indeed the classic 'Kanavel hand' arises when deep palmar suppuration extends *'Kanavel hand'* along the lumbricals to the web spaces, there to discharge spontaneously through multiple sinuses.

(3)—Diagnosis

The diagnosis of infection of the hand and fingers is usually self-evident; but the determination of its site and localization is much more difficult and of much greater importance. It has already been pointed out that the position of maximum swelling is not an accurate guide to the location of the infection. Thus, in inflammation of the palmar and thenar spaces the maximum swelling is always seen on the dorsum of the hand. The position of maximum tenderness is of greater value, but even this does not give any indication of the depth of the infection. By carefully noting the limits of tenderness, however, it may be recognized that they correspond to some definite anatomical structure or space, and thus the site of the infection will be determined. *Determination of site of infection*

When the thecae are involved, there will be pain upon all movements *Pain*

of the finger concerned, both active and passive. Pain upon movement in one direction only may arise when the infection lies outside the sheath, if the part is compressed by the movement. A careful consideration of these cases will usually show that some movement is possible in the opposite direction without producing pain, and so indicate that the infection is not in the sheath. Pain due to infection in the joints also occurs from movements in any direction, but in these cases pressure along the longitudinal axis of the digit will elicit pain, whereas this manœuvre is practically painless when the theca only is involved. End pressure upon the nail produces local pain in the case of onychia or when the terminal phalanx is affected.

Suppuration in the nail-bed can often be seen through the translucent substance of the nail.

Infection of spaces

Infections of the palmar and thenar spaces produce local tenderness and a fullness of the corresponding side of the palm with obliteration of the normal hollow. If the anatomical limitations of these spaces are remembered, there will be little difficulty in saying which space is involved, but, in addition, the situations of the swellings in the web spaces and on the dorsum of the hand will afford corroborative evidence. The inner three web spaces are affected when the palmar space is involved, and the first web space and, sometimes, the second when the thenar space is affected. Fullness of the palm, best marked on the ulnar side, is produced also by infection of the palmar bursa, but this can be distinguished by noting that the swelling extends above the transverse carpal ligament, and that the movements of all the fingers are extremely limited and painful in the early stages. A swelling above the transverse carpal ligament may also be due to infection of the deep space of the forearm, by extension from the palmar space. This, however, will be less well defined than the bursal swelling, and will arise at a later stage of the disease, when the palm is already extensively involved.

Lymphadenitis and lymphangitis

To complete the examination, a search must be made for lymphadenitis in the axillary glands, rarely in the epitrochlear also, and for lymphangitis. The superficial lymphatic vessels for the most part travel in a spiral fashion, passing from below upwards and inwards around the forearm. The red, tender, and indurated streaks of a lymphangitis follow this course.

General condition of patient

Finally, the general condition of the patient must not be overlooked. The extent of increase in temperature and pulse and the occurrence of rigors are important diagnostic features, and the presence and degree of leucocytosis may be a valuable guide in treatment and prognosis.

(4)—Pre-Operative Considerations

Identification of infecting organism

Before rational treatment can be undertaken it is necessary to consider, in addition to the above anatomical points, the type and virulence of the infecting organisms, for the conduct of the case depends upon this as much as upon the site of the inflammation. The organisms most commonly found are staphylococci and streptococci. Of the former,

Staphylococcus aureus is especially virulent and may produce a cellulitis and lymphangitis not unlike those seen in streptococcal infections. The well known predilection of this organism for bones will naturally arouse a suspicion of bone involvement. A lymphangitis can, however, usually be accepted as evidence of a streptococcal infection, especially if it is associated with a rather wide-spread local infection which displays little tendency to localization or to suppuration. Sometimes, when a wound is already present, the organism may be identified by bacteriological methods, and if possible this should be done. More frequently, the nature of the infection must be decided from clinical observation only. In the presence of lymphangitis, lymphadenitis, high temperature, and rigors, the infection may be assumed to be streptococcal, and treatment instituted accordingly. If involvement of bones or joints is suspected, a radiograph should always be taken before the diagnosis is considered complete.

It cannot be too strongly urged that the preliminary examination should be thorough, for only in this way can a complete picture of the case be formed, without which efficient treatment is impossible. In the majority of people the hand is the most important part of the body from the economic point of view, and its disablement usually results in a very severe limitation of the owner's ability to remain an active, self-supporting individual.

The classification of infections of the hand and fingers according to the structures first invaded, e.g. subungual whitlow, conveys an idea of isolated lesions which is quite opposed to the great tendency which these infections show to spread rapidly. Such a view is apt to lull the practitioner into an unjustifiable sense of surgical security, which may cause delay in proper treatment and have tragic results.

(5)—Treatment

(a) *Prophylaxis*

It has been pointed out that many of these cases arise from wounds and injuries, so that, except for certain difficulties already considered, it would appear feasible to prevent the complication of infection in a large number of cases. In the hand, with its anatomical complexity and the contraction and retraction of structures after division, this will only be achieved when it is more widely appreciated that it is an error to attempt immediate closure. Most of these wounds are quite incapable of complete immediate sterilization, and they should therefore be left widely open and packed lightly with antiseptic gauze (flavine) after a preliminary cleaning up. A few days later a secondary suture can be attempted without fear of gross infection. Divided structures may have an identifying suture passed through them, to prevent retraction and to aid in recognition at the secondary suture. The punctured wounds, e.g. those produced by needles, present a different problem in prophylaxis. If the penetration is known to be of very limited extent, it may be proper to attempt sterilization by the passage, along the track, of the

*Prevention
of wound
infection*

eye-end of a needle dipped in phenol. In most cases, however, it is wise to avoid the use of strong antiseptics, and to rely upon suction and the use of a congestive bandage above the part for twenty-four hours or so.

(b) *General Treatment*

Rest In the treatment of these cases the general principle of rest to an acutely inflamed part should be applied, whether operative treatment is adopted or not. Rest tends to limit the spread of the infection, and is particularly useful when the thecae are threatened or involved. It is achieved by

Splinting appropriate splinting. Often the best form of splint to use is one constructed of stout wire, bent by the surgeon to suit the individual requirements of the case, while allowing the necessary dressings to be applied without undue disturbance. There is no need here to detail the construction of these splints, the efficiency of which is often a measure of the mechanical ingenuity of the practitioner.

Streptococcal cases If the suspicion arises that the case is due to a streptococcus, special caution is necessary in its conduct. Since violent streptococcal infections, here as elsewhere, are associated with some degree of septicaemia in the earlier stages, and there is little tendency to localization, operative treatment should, with certain exceptions given later, be avoided. The old idea of making multiple incisions into the infected area, 'to relieve tension', has little to recommend it, and may be definitely harmful by helping to spread the infection and by breaking through any resisting barrier which may be forming.

Treatment in initial stages In the initial stages the treatment of such cases should be along general lines; in particular, the administration of large quantities of glucose and the injection of considerable doses of antitoxic sera should be relied upon. The new chemotherapeutic products of the sulphonamide type, e.g. prontosil and prosepilase, are of proved value and may be used as a substitute for the serum with advantage (see Vol. V, p. 157). Lymphangitis and lymphadenitis are similarly dealt with. If the infection is very superficial (erysipelas), ultra-violet rays have a definite limiting effect and are of great value. Blood transfusion may be of use if the leucocyte count shows that the patient's reaction is poor.

Operative treatment The rule that streptococcal infections should not be treated by operation is subject to two important exceptions. If the vitality of a digit is threatened by the extreme tension of the exudate, which is obviously interfering seriously with the blood-supply, some small incisions into the subcutaneous tissues are proper, in an attempt to reduce the tension and so save the finger. The second indication arises in the later stages, when frank suppuration has occurred. The appearance of localized pus in a streptococcal case is a sign that the patient's resistance is dealing adequately with the infection, and, in these circumstances, drainage may be instituted as for other infections.

Scope of surgical treatment Except for the acute streptococcal cases, infection of the hand and fingers should receive energetic surgical treatment in as early a stage as

possible. Damage may be done both by delay and by too vigorous and extensive initial treatment, but there can be no doubt that the commoner errors are those of delay and timid surgery. An early infection is sometimes dealt with by a minute incision under the ethyl chloride spray, which lets out a bead of pus but fails to arrest the spread at the periphery. The surgeon probably thinks that a larger incision will take a long time to heal, forgetting that a wide-spread infection, inadequately treated, will take much longer still and lead to great disability.

These cases must be treated in no half-hearted manner, but, as a corollary to this, it is most important that the surgeon should have a clear idea of what he wants to do and of the anatomy of the parts, so that he can design his operation to produce proper drainage without endangering any important structures and without spreading infection or producing disability by his incision. Every case must be carefully worked out on its merits, but there are certain general rules which form a very valuable guide in the majority of instances. It must be emphasized that all operations of this type should be performed deliberately, under full general anaesthesia, with good illumination, and, preferably, in a properly equipped operating theatre. To attempt to drain an infected hand or finger (other than a very superficial infection) in the surgery or casualty department, under a short anaesthesia, is courting disaster. Local anaesthesia is usually not suitable for these cases, with perhaps the exception of the terminal phalanx, where regional anaesthesia may be produced by circumferential infiltration at the base of the digit. Even so, I much prefer general anaesthesia, gas and oxygen being quite suitable, as there is no need for great muscular relaxation. The use of a tourniquet is often advisable, but it must remain on for a short time only, lest devitalization of the inflamed tissues should occur.

*Principles
of operative
treatment*

(c) Incisions

Infection of the pulp should be dealt with by an incision skirting the end of the finger, about one-eighth of an inch from the nail margin, which it follows (see Fig. 24). The whole pulp is raised as a flap from off the underlying bone, and the wound kept widely open by packing with flavine gauze. In this way the loculi previously mentioned are drained, for this incision cuts across the bases of them all, the spread of infection rapidly ceases, the bone, unless already involved, is saved, and the flap readily falls back into position with an intact nervous and vascular supply. The final scar is obviously well removed from all pressure points. In exceptional cases one half only of the flap is raised; this is especially useful when one side of the nail groove is involved; or the pulp may be transfixed to reach a small central infection.

*Infection of
pulp*

Infections under the nail are best dealt with by removal of that structure, either *in toto* or in part. When the root is involved, as in onychia, two lateral vertical incisions are made for about half an inch, continuing the line of the lateral nail groove. The whole skin flap thus outlined is raised from off the nail root and packed as above.

*Infections of
nail*

Superficial infections in the intermediate and proximal sections of the digit are drained by lateral incisions which avoid the nerves and vessels by keeping well on to the palmar aspect (see Fig. 24). These incisions into the subcutaneous tissues may cross the skin creases with impunity.

*Drainage of
thecae*

Drainage of the thecae is a more difficult problem. If the whole length of a theca were to be opened by a median incision, adequate drainage would undoubtedly be established, but the tendons would retract out of the wound like a bow-string. It is true that this might be avoided by splinting in complete extension, but dense anterior adhesions would form, which it would be impossible to break down subsequently. In addition, the sheath would be weakened at its most important part, and the scar would be right over the pressure area. For these various reasons the incisions are usually made in a bridged fashion (see Fig. 24), leaving the intervening portion of the theca intact. They are placed at the lateral borders of the sheath.

With these stipulations, the incisions should be as extensive as possible. The extension of a theca into the palm may be drained by a median incision, care being taken, in the case of the index finger, of the vessels and nerves which cross it (see p. 186). There is some divergence of opinion about the best position in which to fix a finger in these cases. If the theca is not divided in its

FIG. 24.—Diagram to illustrate common incisions used for drainage of fingers and hand. *a*, Circumferential incision for drainage of pulp; *b*, flap raised in cases of onychia; *c*, for drainage of flexor digital sheaths; *d*, for proximal ends of these sheaths; *e*, for long flexor of thumb; *f*, for sheath of flexor of little finger; *g*, for common flexor bursa

*Fixation of
finger*

whole length, there is little fear of tendon prolapse, and a somewhat flexed finger is much easier to manipulate subsequently than one which is fully extended. Difficulties may arise when it has been impossible to say before operation whether or not the theca is involved in the infection. In these circumstances the surgeon should dissect carefully down to the theca first; if it is obviously infected it can then be opened; if it is doubtful, the wound can be left widely open, and a fresh observation made in twenty-four hours. In exceptional cases, the discreet use of a needle and syringe may decide the issue.

(d) Drainage of the Palm

Infections of the palmar and thenar spaces must not be dealt with by incisions into the palm. The routes by which these infections naturally spread have already been outlined, and it is along this same track that the surgeon should attempt to institute drainage. The incisions therefore are made in the appropriate web spaces, and, from these, sinus forceps are carefully pushed into the deep spaces until pus is reached. Drainage may be maintained by keeping the tracks open with strips of thin glove rubber. Drainage tubes should not be used, owing to the great risk of causing pressure necrosis and secondary haemorrhage.

*Drainage of
palmar and
thenar spaces*

The proper drainage of the theca of the thumb and of the main palmar bursa demands a high degree of skill: otherwise considerable damage may be done to the important structures which are crowded together in this region. In these cases incisions should be made into the palm: that for drainage of the thumb theca skirts the inner margin of the thenar eminence, and that for the palmar bursa keeps well to the ulnar side and skirts the hypothenar eminence. In the deeper dissection on the thenar side great care must be taken to avoid the branches from the median nerve to the small muscles of the thumb. In the case of both the common flexor and the thenar bursae the incision is interrupted at the transverse carpal ligament, for division of this structure would result in considerable weakening of the whole of the hand and fingers. The incisions are, however, resumed in the forearm, proximal to this ligament, the upper ends of the bursae being efficiently drained by this route.

*Of theca
of thumb and
main palmar
bursa*

(e) Involvement of Bones

Involvement of bones will be very largely avoided if early and adequate drainage of superficial infections is instituted. Bone infection, especially of the terminal phalanx, may be suspected if the wound does not readily close, if the finger remains swollen, or if fresh abscesses and sinuses form. The use of a probe will reveal necrotic bone, and in these cases, although not in the initial stages, a radiograph is of great value.

*Diagnosis
of bone
infection*

At the earliest possible moment the cavity should be laid freely open and all necrotic bone removed. The functional result following necrosis of the terminal phalanx, when the soft tissues have not been allowed to become extensively destroyed, is good. Necrosis and sloughing of tendons are usually due to wide-spread infection of their sheaths and may be very largely avoided by adequate early drainage. A dead tendon must be removed, since it is otherwise a source of prolonged suppuration, and there is nothing to be gained by its retention. At a later date the question of a plastic operation or of amputation of the digit will have to be considered.

Treatment

Basal-celled epitheliomas are never encountered on the palm and are very rare on the dorsal aspect; they present the characteristic rolled-over edge and other features seen elsewhere. Epitheliomas usually result from one of the carcinogenic agents mentioned above but occasionally occur spontaneously. In the former instances they are commonly preceded by multiple warts or a generalized hypertrophic condition of the epidermis. The epitheliomas do not present any unusual features. Epitrochlear and axillary glands are involved after a moderate interval. The growths are radiosensitive and in the earlier stages, except those produced by X-rays, should be treated by radium. For more extensive growths the application of radium is preceded by local excision, with dissection of the invaded glands, and for cases which have become insensitive to radium amputation is the ultimate treatment. *Epithelioma*

Melanomas may start in pigmented moles, as elsewhere, but a particularly misleading form in the hand is that beginning in the nail-bed. For a long time it may be mistaken for a subungual whitlow or haematoma, and only when the disease is too far advanced for treatment to be of any avail is the nature of the disease recognized. This error would be avoided if the possibility were constantly borne in mind. The prognosis is bad, but some cases have done well with early amputation of the finger and dissection of the glands. *Melanoma*

Bone sarcoma may occur in the metacarpals, where it is frequently osteo-formative and therefore easily detected by radiography. Central bone sarcoma also has been seen in the phalanges but is extremely rare. *Sarcoma of bone*

5.—CHRONIC INFLAMMATORY AND MISCELLANEOUS CONDITIONS

617.] A digital chancre, usually on the index finger, is particularly likely to occur in medical practitioners and dentists. It is common on the dorsal aspect around the nail-root, and has often been mistaken for a simple onychia until the secondary signs have appeared. *Syphilis*

In any case in which infection has been possible the discharge should be examined for the *Treponema pallidum* by dark-ground illumination; any superficial lesion, not communicating with bone, which fails to clear up rapidly under antiphlogistic treatment should suggest the possibility of a syphilitic infection.

The secondary rashes of syphilis are well displayed on the palms of the hands, especially the pemphigoid and scaly rashes, but gummatous formation in the tertiary stage is uncommon in the hand. *Syphilitic rashes*

Verruca necrogenica is another condition to which surgeons and pathologists are prone; it consists of a small warty outgrowth on the knuckles which is caused by the implantation of a local tuberculous infection during an operation or post-mortem examination. *Verruca necrogenica*

In addition to such tuberculous warts, tuberculosis produces two other distinct infections of the hand. In infancy and childhood a tuberculous

Tuberculous osteitis

osteitis of the metacarpals or of the phalanges is seen. It is peculiar in that, side by side with central rarefaction, there is new bone formation at the periphery, which is unusual in tuberculosis of bone in the absence of secondary infection. The result is a swollen spindle-shaped digit (*spina ventosa*). Occasionally the process bursts through its capsule and discharges on the surface, leaving a typical tuberculous sinus. Treatment is usually conservative, but in some cases the bone must be opened, curetted, and packed.

Tuberculous tenosynovitis

In adults a tuberculous tenosynovitis of the large palmar bursa (common flexor sheath) is met with and termed compound palmar ganglion. The condition produces a characteristic hour-glass swelling which can be detected both above the wrist and by the fullness of the palm. There is through fluctuation between the swellings, and movements of the fingers are very limited and painful. If the condition progresses, the tendons are eroded and may undergo spontaneous rupture. The bursa is filled with a thin fluid in which are enormous numbers of melon-seed ('rice') bodies.

Treatment is primarily by complete rest, accomplished by enclosing hand and fingers in a suitable plaster splint; at the same time all the general anti-tuberculous measures are adopted. If the case is resistant to conservative treatment, the bursa must be opened above and below the wrist and all tuberculous material removed by curettage and gauze dissection. The cavity may be packed with formalin 2 per cent in glycerin and the wound closed. Subsequent splinting for a long period is essential.

Ganglion

The extensor tendons of the wrist are among the commonest sites for a simple ganglion, but ganglia may at times be found in other positions on the hand. The exact pathology of these common swellings remains in doubt. They have been variously ascribed to hernial protrusions of synovial membrane of the tendon sheaths, to myxomatous or mucoid degenerations in tendons, ligaments, and aponeuroses, and to delayed activity of rests of the original myxomatous tissue of the limb buds. Since they may occur in situations where there are no synovial sheaths, it is clear that the first hypothesis cannot account for all cases. Their well established association with trauma, usually repeated minor injuries or overstrain, suggests that the second view is the most likely one.

Clinical features

On the dorsum of the hand and wrist they often occur in typists and others who use their fingers on percussion machines or instruments. Their appearance is sometimes preceded by an aching pain on movement which is very suggestive of rupture of a few tendinous fibres. They grow slowly until they reach the size of an almond nut, and they usually remain more or less stationary. There are slight disability, weakness, and aching pain after use of the wrist. For this and for cosmetic reasons treatment is usually necessary.

Treatment

The ancient method of subcutaneous rupture is not very satisfactory and may even lead to the production of multiple tumours. Clean excision, where it can be performed without anatomical damage, is best.

For the occasional complicated ganglion involving many tendons, e.g. at the base of the thumb, complete excision becomes almost impossible, and the cavity may then be well opened and packed with plain sterile gauze. The packing is renewed at intervals until healing is complete. A simple method of treatment for small ganglia, which, although not invariably successful, is nevertheless worth a trial, is the insertion across the base of the swelling of setons of sterile thread soaked in iodine solution. The contents of the ganglion are squeezed out through the needle apertures, and steady pressure is then maintained for fourteen days by suitable dressings. The setons are then removed.

The contents of the ganglia vary in consistence from a thin glairy fluid to a thick jelly. In some cases it is possible to aspirate the ganglion contents through a thick needle and then to inject some irritant chemical material, e.g. iodine or phenol, which, like the seton, sets up a chemical inflammation that may lead to obliteration of the cavity.

A painless whitlow may appear in association with certain spinal cord lesions, particularly syringomyelia; in this disease too neuropathic changes in the joints occur in the upper limb, including the wrist and hand, and are very prone to secondary suppurative changes. *Whitlow*

Trophic ulcers, of vascular rather than nervous origin, are seen on the finger-tips in severe cases of Raynaud's disease. *Raynaud's disease*

In rheumatoid arthritis the fingers of the stiffened hand pass into a position of ulnar deviation which is very characteristic (see Vol. II, Fig. 22, p. 78). In gout large tophi appear, especially around the knuckle-joints, and cause gross deformity. They may penetrate the surface and discharge a milky fluid containing sodium biurate crystals in abundance (see also GOUT, p. 43). *Rheumatoid arthritis and gout*

Simple saccular aneurysms occur in association with both the radial and the ulnar arteries, usually as a sequel to trauma; they are easily dealt with by incision, the presence of the palmar arches ensuring an adequate blood-supply to the hand. *Aneurysms*

Arteriovenous communications are uncommon at this level, but the hand may show the changes of a communication higher up, and so be generally expansile and have a thrill and bruit. Similar changes, in a more marked degree, are seen in congenital cirroid aneurysm; here in addition to the pulsation, thrill, and bruit, the whole of the soft structures of the hand may be tremendously hypertrophied and elephantoid, and the bones display a patchy rarefaction due to the increased blood-supply; the radiograph also shows multiple calcified arterioliths in these cases.

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HARE-LIP

See PALATE, CLEFT

HAY-FEVER

See ALLERGY, Vol. I, p. 313

HEADACHE

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OF THE NOSE	COMPRESSION
BILIOUSNESS	EAR DISEASES
BLOOD-PRESSURE,	HYDROCEPHALUS
HIGH AND LOW	LEAD POISONING
BRAIN ABSCESS	MENINGITIS
BRAIN: REGIONAL	MIGRAINE
DIAGNOSIS	NEPHRITIS AND
BRAIN TUMOUR	NEPHROSIS
BRAIN: VASCULAR	SYPHILIS
DISORDERS	

1.—AETIOLOGY

618.] Knowledge of those parts of the head which are sensitive to pain and of the nerves which conduct the sensations of headache goes little deeper than the scalp. The observations of surgeons operating under local anaesthesia have shown that pressure or traction upon the dura mater may cause pain if the stimulus is severe. This is true also of the meningeal arteries. The brain is insensitive to mechanical or thermal stimulation. After section of one trigeminal nerve it is found in most

*Stimulation of
dura mater
and meningeal
arteries*

cases that headache, from whatever cause, is no longer experienced on that side of the head.

Intracranial pressure

It was long assumed that the headache of increased intracranial pressure was due to expansile tension upon the dura mater. This explanation, however, will not meet the facts of observation. Headache may be present in cases of intracranial tumour when the ventricular pressure is normal: it may be absent when the ventricular pressure is twice its normal height. Indeed, in such cases a sudden reduction of pressure from tapping the lateral ventricle may induce headache. Northfield, in a critical review based upon his own observations, concluded that the dura mater was not the sensitive structure responsible for the characteristic headache of intracranial tumour, and suggested that the headache was caused by a state of abnormal tension in the walls of the cerebral blood-vessels. Such an explanation has the merit of being wide enough to cover the many headaches from different causes in which it is difficult to suppose that the dura mater or meningeal vessels are subject to direct stimulation.

As a symptom of many diseases headache is common and often prominent. It is common also, in the form of migraine, as the sole manifestation of a morbid tendency.

Idiosyncrasy

Apart from these diseases headache not uncommonly occurs in many persons without any very important cause. Some suffer readily from headache, for instance, as the result of a stuffy or thundery atmosphere, worry, fatigue, indigestion, insufficient sleep, or a slight infection or intoxication. At the other extreme it is not exceptional to meet with those who have experienced the ordinary vicissitudes of life and ill-health yet do not know from personal experience what headache means. This factor of personal idiosyncrasy deserves due consideration in assessing the value of headache as a symptom. Children rarely suffer from headache without some cause to which a name can be given. Among adults casual headaches are often without serious significance.

2.—CLINICAL EXAMINATION

Methodical inquiry in the case of a patient complaining of headache will sometimes yield information which at once suggests the true cause.

Questionnaire

The following questions should be asked: (i) What is the nature of the pain? (ii) What parts of the head are involved? (iii) Is the pain continuous or intermittent? If the latter, how frequent are the attacks? How long do the attacks last? At what age did they begin? Does the attack occur at any particular time of day? Is it preceded by an aura? (iv) By what factors, if any, is the attack provoked or aggravated? Is it related to physical effort, such as coughing, straining, or change of posture, or to mental strain or fatigue? (v) What are the associated symptoms? General malaise? Depression or insomnia? Nausea or vomiting? (vi) Has the development been immediately preceded or

accompanied by any injury to the head or by disease affecting the eyes, nose, ears, or teeth? Interrogation on these lines, followed by physical examination, including that of fundi, blood-pressure, and urine, will usually reveal the cause of any headache which has an important meaning. Inspection of the head by sight and touch should not be omitted. *Physical examination*

3.—TYPES OF HEADACHE

Headache due to toxic or infective causes is usually described as a fullness or throbbing, is of frontal or general distribution, continuous rather than intermittent, and aggravated both by physical and mental effort. In the infective group the diagnosis is usually made easy by the associated symptoms, malaise, loss of appetite, and fever, or as the result of physical examination. Nevertheless, I have met with several cases of ambulant fever, especially of the enteric group, in which the predominance of headache and the absence of febrile symptoms had led to neglect of the thermometer. *Infective*

Toxaemic headaches also are associated as a rule with symptoms and signs to prove the diagnosis. Severe headache may be the first symptom of uraemia (see NEPHRITIS AND NEPHROSIS) or of lead poisoning. Constipation is often alleged to be a cause of headache, and it is true that many persons complain of a sense of fullness or dullness in the head if they fail to obtain their routine evacuation. This headache, being immediately relieved by defaecation, must be reflex rather than toxic (see Vol. III, p. 381). *Toxaemic*

Neurasthenic headache is usually described in terms of discomfort rather than pain, even though in the patient's mind his suffering may amount to agony. It is a pressure upon, a tightness around, a numbness, wooden feeling, or dullness in the head, often generalized, sometimes vertical or occipital. It is more often than any other headache quite continuous over a long period, weeks, months, or even years. The associated symptoms are depression, anxiety, insomnia, indecision, and difficulty in concentration. Often headache is the leading symptom in mild states of depression or anxiety. The patient feels that, if only he were free of the headache, he would be happy and well, whereas in truth headache and depression are separate symptoms of the same illness. Often in these depressive states headache and mood are at their worst in the earlier hours of the day, and there is a lifting of the cloud in the evening. *Neurasthenic*

The distinctive features of migraine (see MIGRAINE) are its occurrence in attacks which are short-lived and separated by intervals of complete freedom, the onset in youth, a family history of similar attacks, the common occurrence of vomiting, and the aura, which, if present, is distinctive. *Migraine*

Increased intracranial pressure causes headache which is generally of a throbbing, bursting, or piercing character. It may be referred to any *Intracranial pressure*

or every part of the head but is often most severe in the frontal and suboccipital regions. In subtentorial tumours it is apt to radiate into the back of the neck (see Vol. II, p. 630). It is intermittent, occurring at first in bouts usually lasting an hour or two, often restricted to the early morning. It is provoked or aggravated by physical effort, stooping, or straining, and is often associated with vomiting. The other associated symptoms are usually those of a cerebral tumour (see Vol. II, p. 627). Examination of the fundi is essential, but the absence of papilloedema is compatible with increased intracranial pressure of some standing (see PAPILLOEDEMA). Headache of this type may also occur in an exacerbation of arterial hypertension (see Vol. II, p. 511).

Eye-strain

Headache due to eye-strain is as a rule dull in character, frontal or supra-orbital in situation, is noticed at night or in the early morning, and follows prolonged visual attention, often associated at the time with a sense of undue effort. Supra-orbital headache on the affected side may occur as the leading symptom of acute glaucoma (see Vol. V, p. 580).

Dental caries

Dental caries is a not uncommon cause of pain referred to the head, the molar teeth being usually responsible. From the lower jaw the pain is referred to the temple and may radiate upwards. When the diseased tooth is in the upper jaw, pain in or behind the eye on that side may be the prominent symptom.

*Disease of
the nose and
accessory
sinuses*

The headache of frontal sinusitis is often severe and throbbing and is referred to the supra-orbital region on one or both sides. When the infection is acute, as in the course of coryza, the pain is continuous and aggravated by physical effort and bright light. A chronic empyema of one frontal sinus may cause headache referred to that side, which occurs in bouts lasting several days, on each of which the pain begins almost at the same hour, usually in the mid-morning, and lasts until mid-afternoon. Chronic infection of the ethmoidal cells or the sphenoidal sinuses may cause pain of an aching character, referred to the brow or eye on one or both sides, occurring in bouts, and aggravated or provoked either by physical or mental effort, the latter especially if eye-strain is involved. Occipital headache also may occur in sphenoidal sinusitis (see ACCESSORY SINUSES OF THE NOSE, Vol. I, p. 77). Obstruction of the nasal passages in the absence of inflammation has, in my opinion, been saddled with an undue share of responsibility for headache.

Otitis media

Headache in association with otitis media (see Vol. IV, p. 412) suggests some deep extension of the infection. Involvement of the mastoid cells alone does not as a rule cause headache. When the petrous bone is affected, and especially if its apex is involved, pain occurs of a boring or shooting character, referred to the temple and brow, intermittent, and often worse at night. Extra-dural abscess in the middle fossa causes headache of similar type and distribution. In extra-dural abscess of the posterior fossa the pain is referred mainly to the suboccipital region but may radiate forwards as far as the brow. The headache of cerebral or of cerebellar abscess (see Vol. II, p. 598) is of the same kind

*Extra-dural
abscess*

as occurs in tumours in the same situation (see Vol. II, p. 630). Any one of these complications of otitis media may cause headache at a time when the infection in the middle ear is quiet. *Cerebral and cerebellar abscess*

Headache is a common complaint in Menière's disease, either in association with the attacks of vertigo or occurring separately (see VERTIGO). It may be dull, wide-spread, and continuous, or of a more severe aching and intermittent character, with reference to the back of the head on the side of the affected labyrinth. *Menière's disease*

Traumatic headache is polymorphic. At least three types may be distinguished. One is of the kind already described as neurasthenic (see p. 201), and the associated symptoms are those of the same group. Another takes the form of a sharp, shooting, or throbbing pain, circumscribed and often referred to the site of the injury, short-lived, and occurring spontaneously or as the result of physical effort or stooping. A third and much less common form is of the kind met with in increased intracranial pressure and may continue to occur in occasional bouts long after the injury. *Trauma*

Fibrositis of the scalp or of the suboccipital tissues is an occasional cause of headache. In the suboccipital region the greater occipital nerve may be involved with reference of the pain forwards to the mastoid region, above the ear, and into the temple. Whatever the situation of the pain its character is as a rule shooting, stabbing, or aching. Sometimes there is a tingling quality. It is apt to be continuous over a period of days or weeks, with occasional exacerbations. It may be aggravated by movement of the head or neck, coughing, and sneezing. It is almost always associated with tenderness of the affected part. This is easily discovered when the trouble is in the scalp; when the pain arises from involvement of the greater occipital nerve, tenderness is elicited only by deep suboccipital pressure. *Fibrositis*

Chronic meningitis, usually syphilitic, causes pain which is severe, often of a boring or shooting character, and referred to any part of the head. It may be continuous and is often worst at night. The association with cranial nerve palsies or abnormalities of the pupils is important. (See MENINGITIS.) *Meningitis*

4.—PROGNOSIS AND TREATMENT

The prognosis and treatment of headache are related to its cause and are dealt with under the appropriate titles. For symptomatic relief all sorts of drugs have been tried, and new ones are constantly being put upon the market. Personal idiosyncrasy is such that a new preparation is often worth a trial, but for most sufferers from headache acetyl-salicylic acid (aspirin) remains the favourite remedy. The difficulty with some persons is that it causes indigestion, but this can usually be overcome if the patient avoids taking it on an empty stomach, swallowing if necessary half a glass of milk or a tablet of chocolate beforehand,

and if instead of taking the solid tablets he moistens and powders them in a spoon. If, notwithstanding these precautions, the difficulty persists, the ingestion of an equal quantity of sodium bicarbonate will often remove it.

Sometimes better results are obtained by giving aspirin with other analgesic drugs, such as phenacetin and amidopyrine. For example, two or three compound aspirin tablets B.P.C., each containing aspirin 3·5 grains, phenacetin 2·5 grains, and caffeine 0·5 grain, may be taken for one dose. A powder containing 5 grains each of aspirin, phenacetin, and amidopyrine as a single dose may be useful, or one or two tablets of veganin, each of which contains aspirin 4 grains, phenacetin 4 grains, and codeine phosphate $\frac{1}{6}$ grain, may be prescribed. For occasional use to relieve headache of exceptional severity a powder containing 5 grains each of aspirin and phenacetin and $\frac{1}{6}$ or $\frac{1}{8}$ grain of diamorphine hydrochloride is most effective, but the risk of addiction must be borne in mind.

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ARTERIAL DISEASE AND	LIVER DISEASES
DEGENERATION	LUNG DISEASES
ASCITES	NEPHRITIS AND NEPHROSIS
BLOOD-PRESSURE,	OEDEMA
HIGH AND LOW	RHEUMATIC INFECTION,
CHOREA	ACUTE
CYANOSIS	SYPHILIS

I.—CONGENITAL DISEASES

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1.—DEFINITION

619.] The term congenital heart disease is applied to structural anomalies of the heart or great vessels due to an arrest or disturbance of development during embryonic life or, occasionally, to foetal disease.

2.—AETIOLOGY

The distribution of congenital heart disease is highest in infancy and childhood and diminishes as age advances, owing to the high mortality in early life. The incidence of congenital heart lesions at the Johns Hopkins Hospital was 1.29 per cent in 13,115 necropsies (Leech) and at the Massachusetts General Hospital 0.9 per cent in 7,500 necropsies (McGinn and White). Clinical statistics show that congenital heart disease constitutes 1.5 to 2.5 per cent of all cases of organic heart disease and about 11 per cent of all cases of organic heart disease in children over two years of age (Wilson *et al.*). *Age incidence*

The ratio of males to females is about 4 to 3 in Abbott's statistics (1932 and 1936) and 6 to 5 in Peacock's, but in a personal series of 259 clinical cases it was 10 to 11. *Sex incidence*

It is peculiar that subaortic stenosis, aortic atresia, bicuspid aortic valves, coarctation of the aorta, transposition, and Fallot's tetralogy are commoner in males, whereas the patent ductus arteriosus, the *maladie de Roger* (isolated interventricular septal defects), and interauricular septal defects are commoner in females.

3.—PATHOGENESIS

*Develop-
mental
anomalies**Ontogenetic
arrest**Critical
period*

J. F. Meckel, in 1812, drew attention to the resemblance between the malformed human heart and the normal hearts of the reptiles, amphibians, and crustaceans; it has since been shown that the embryonic human heart at successive stages in its development bears comparison with the hearts of the lower vertebrates, ascending through the phylogenetic scale. Most of the congenital malformations may be accounted for by an arrest of development or by an interference with normal development at some particular stage of embryonic life. The earlier this arrest occurs, the more complicated and serious is the resulting deformity. Thus interference with growth at an early stage may lead to gross defects, such as a two-chambered or a three-chambered heart, comparable with the hearts of fishes and reptiles; at a later stage, when the septa are almost complete, an arrest of growth leads to defects in the septa without involvement of the pulmonary tract. The critical period of development is from the fifth to the eighth week of intra-uterine life, during which the septa are forming, the bulbus cordis is undergoing involution, and torsion of the great vessels is taking place. Keith explained pulmonary stenosis with ventricular septal defect as due to arrest in the evolution of the bulbus cordis, which normally becomes incorporated in the right ventricle to form the infundibulum. Unusual relationship between the different parts of the heart may be explained by interference with the normal process of torsion of the primitive cardiac tube. Transposition of the great vessels was explained by Rokitansky as due to the deviation or malunion of the aortic and interventricular septa. Complicated anomalies are explained by Spitzer as due to failure of the normal process of clock-wise torsion of the arterial trunks, or to detorsion in a counter-clockwise direction. According to Spitzer's hypothesis Fallot's tetralogy involves detorsion and a persistence of the reptilian right aorta.

*Foetal
disease*

Foetal disease probably plays a minor part in the aetiology of congenital heart disease. The valvular form of pulmonary stenosis with closed ventricular septum is generally attributed to late foetal endocarditis. Foetal myocarditis, due to syphilis or other infections, is more important than endocarditis in the causation of atresia or stenosis of the aortic and pulmonary orifices (Abbott, 1927). Congenital idiopathic hypertrophy of the heart is most often associated with inflammatory myocardial changes, abnormalities of the coronary vessels, or glycogen disease (see Vol. V, p. 589).

Although embryology and comparative anatomy can account for the structural defects which constitute congenital heart disease, nothing is known of the forces which disturb the normal development of the foetal heart. Abnormality of the germ plasm, heredity, and the maternal condition have to be considered. In many cases of congenital heart disease—in 18·8 per cent of Abbott's series (1932)—there are associated

anomalies of other parts of the body, e.g. transposition of the viscera, cleft palate, skeletal deformities, and mongolism. Direct heredity cannot be an important factor, because few of the subjects reproduce, but the recurrence of congenital anomalies in other members of the same generation is not uncommon. This points to some defect in the parents, especially in the mother; physical and mental traumata in the early weeks of pregnancy and pathological conditions of the uterus and amnion have been blamed. Mongolism is prone to occur in the last of many pregnancies and with elderly parents (see p. 460). Consanguinity, alcoholism, syphilis, and tuberculosis in the parents have been considered as possible factors.

Associated anomalies
Heredity

Parental defects

Other factors

4.—CYANOSIS

The cyanosis of congenital heart disease was attributed by Senac to an intermixture of venous and arterial blood, but this explanation was not readily accepted, because a free communication between the two sides of the heart was sometimes found post mortem in cases without any cyanosis. Peacock and many others, following Morgagni, held venous stasis to be the cause of cyanosis. Bard and Curtillet (1889) described the late onset of cyanosis in a case of patent interauricular septum and put forward the explanation that blood had passed through the septal aperture from left to right during the acyanotic phase, and that pulmonary embarrassment, by raising the pressure in the right heart, eventually reversed the flow through the patent septum.

Aetiology

This fundamental observation paved the way for a better understanding of cyanosis and provided the basis for Abbott's and Dawson's classification of congenital cardiac malformations. In uncomplicated septal defects or in patent ductus arteriosus blood will flow from left to right because of the higher pressure in the left heart cavities. This arterio-venous shunt does not affect the composition of arterial blood and therefore does not cause cyanosis. When a septal defect is associated with pulmonary stenosis, there is an obstruction to blood leaving the right heart, and the raised pressure behind the obstruction determines a right-to-left shunt through the septal defect. The entry of venous blood into the arterial stream causes cyanosis. An acyanotic case with a left-to-right shunt may become cyanotic if the shunt is reversed by a rise in pressure in the pulmonary circuit.

The discoloration of the skin in cyanosis is due to an excess of reduced haemoglobin in the capillary blood. Lundsgaard and van Slyke showed that cyanosis became evident when the mean concentration of reduced haemoglobin in the capillary blood exceeded about 5 grams per 100 c.c.; this level represents the threshold for cyanosis and corresponds to 6·7 volumes per cent of oxygen unsaturation. This excess of reduced haemoglobin in the capillary blood may be due to arterial anoxaemia from a veno-arterial shunt in the heart or to capillary stasis, which

Haemoglobin

Threshold for cyanosis

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Associated anomalies
Heredity

Parental defects

Other factors

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Haemoglobin

Threshold for cyanosis

allows a more complete extraction of oxygen by the tissues. In many cases dilatation of the skin capillaries and an increased amount of total haemoglobin are factors which increase the degree of cyanosis. Cossio and Berconsky showed that in some cases peripheral stasis was the main cause of cyanosis, in others a veno-arterial short circuit, and both factors might be operative in the same case. Latent cyanosis may become manifest during exertion, owing to an increased oxygen consumption by the tissues. Oxygen administration has no effect on congenital cardiac cyanosis, because unoxygenated blood reaches the arterial stream without passing through the lungs. (See Vol. III, p. 514.)

Oxygen

5.—CLASSIFICATION OF MALFORMATIONS AND EXPECTATION OF LIFE

*Clinical
groups*

The best clinical classification of congenital cardiac defects is that introduced by Abbott and Dawson, which divides them into three groups as follows:

(1) The acyanotic group, in which there is no abnormal communication between the systemic and pulmonary circuits and therefore no cause for cyanosis.

(2) The potentially cyanotic group (*cyanose tardive*), in which an abnormal communication between systemic and pulmonary circuits exists, through which blood is shunted from left to right. Cyanosis is absent unless the shunt is reversed by pulmonary embarrassment.

(3) The cyanotic group, in which an abnormal communication between the systemic and pulmonary circuits exists, through which blood is shunted from right to left, causing permanent cyanosis. This group also includes a few conditions without a short circuit, in which cyanosis is due entirely to peripheral stasis.

In the following list the more important malformations which are of clinical importance are enumerated under the above three groups. In each case the average and maximum durations of life, cited from Abbott's (1932 and 1936) statistical table of 1,000 necropsies, are given. Lesions that can be recognized during life are described in detail later.

(1)—Acyanotic Group

*Expectation
of life in
acyanotic
group*

(i) Simple dextrocardia with transposition of viscera: duration of life normal. (ii) Bicuspid aortic valves; average 33 years, maximum 68. (iii) Supernumerary aortic or pulmonary cusps; average in former (2 cases only) 36 years, maximum 41; average in latter (8 cases only) 36 years, maximum 80. (iv) Coarctation of aorta, adult type; average 33 years, maximum 92. (v) Right-sided or double aortic arch; average 32½ years, maximum 87. (vi) Subaortic stenosis; average 22½ years, maximum 58. (vii) Aortic stenosis; average 3½ years, maximum 24. (viii) Congenital idiopathic hypertrophy; average 4 months, maximum 4 years. (ix) Congenital heart block; average 7 years, maximum 20.

(2)—Potentially Cyanotic Group

- (i) Patent ductus arteriosus; average 24 years, maximum 66. *In potentially cyanotic group*
 (ii) Defects of interauricular septum: (a) patent foramen ovale; average 29 years, maximum 70; (b) defect of upper part; average 34 years, maximum 64; (c) defect of lower part; average 19 years, maximum 46.
 (iii) Defects of the interventricular septum; average 14½ years, maximum 49. (iv) Defects of the aortic septum; average 14 years, maximum 48.

(3)—Cyanotic Group

- (i) Pulmonary stenosis with patent foramen ovale and closed ventricular septum; average 18 years, maximum 57. *In cyanotic group*
 (ii) Eisenmenger's malformation, ventricular septal defect with dextroposition of aorta; average 13 years, maximum 45. (iii) Cor biatriatum triloculare (single ventricle); average 7½ years, maximum 35. (iv) Fallot's tetralogy, pulmonary stenosis with ventricular septal defect and dextroposed aorta; average 14½ years, maximum 59. (v) Pulmonary atresia with defect of ventricular septum; average 6½ years, maximum 30. (vi) Persistent truncus arteriosus; average 4 years, maximum 25. (vii) Complete transposition of vessels with ventricular septal defect; average 1½ years, maximum 16. (viii) Transposition of vessels with closed ventricular septum. (ix) Pulmonary atresia with closed ventricular septum. (x) Tricuspid, mitral, and aortic atresia. (xi) Simple pulmonary stenosis. (xii) Tricuspid stenosis.

In (viii), (ix), and (x) there is extreme cyanosis and the patients survive less than a year. In (xi) and (xii) there is cyanosis without a short circuit. In (xi) cyanosis is often slight and may be absent.

6.—CLINICAL PICTURE

Many simple congenital anomalies, such as right-sided aortic arch, bicuspid aortic valves, coarctation of the aorta, small apertures in the septa, and patent ductus arteriosus, cause few if any symptoms until complications arise in the form of sclerotic changes or malignant endocarditis. Defects of the interauricular septum may be completely silent until adult life, when secondary mechanical changes in the pulmonary vessels and right heart develop and lead to heart failure.

The most characteristic clinical picture occurs when there is a free communication between the two sides of the heart with a permanent or potential veno-arterial shunt and consists of dyspnoea, cyanosis, clubbing of the fingers and toes, and polycythaemia. Paroxysms of dyspnoea and severe cyanosis, sometimes culminating in coma or convulsions, may occur in infants and children and are due to a temporary reversal of flow through a septal aperture or a patent ductus arteriosus. Epileptiform attacks are not uncommon in association with permanent cyanosis and polycythaemia and are attributable to cerebral

With free communication

Dyspnoea and cyanosis

Epileptiform attacks

*Clubbing of
fingers*

*Poly-
cythaemia*

Cyanosis

anoxaemia or to stasis from increased blood viscosity. Clubbing of the fingers accompanies cyanosis and develops gradually during childhood; the finger-tips become bulbous and broadened and the nails curved (see Fig. 25). Polycythaemia of some degree is usually found with cyanosis and tends to increase in the terminal stages, when the red-cell count may reach 12,000,000 and the haemoglobin be correspondingly increased.

Cyanosis occurs at some stage in about half of all cases of congenital heart disease; it was present in 19 per cent of 291 school children with congenital heart disease under observation by one of us. It may be present at or shortly after birth, may develop during childhood, may be delayed until adult life, or may occur as a transient or terminal event. Transient cyanosis is often seen during fits of crying or coughing, after



FIG. 25.—Clubbing of fingers in congenital heart disease with cyanosis

exertion, or during exposure to cold. The degree of cyanosis varies from a slight heliotrope tinge of the cheeks, lips, and fingers to a deep purplish discoloration of the whole skin and mucous membranes, the conjunctivae being injected, the eyes bulging, and the retinal veins dilated. Even the most severe degree of cyanosis may persist for years in the absence of oedema and other signs of congestive heart failure.

7.—COURSE AND PROGNOSIS

*Cyanotic
group*

The common occurrence of congenital heart disease in school cardiac clinics and its rarity in adult clinics indicate the considerable mortality in adolescence. The outlook is worst in the cyanotic group, many of which die in infancy. Perry stated that in general those cyanosed at birth rarely survived five years, those becoming cyanosed at five years were unlikely to reach puberty, but those becoming cyanosed at or

after puberty might reach adult life. Exceptionally, deeply cyanosed patients reach the thirties, mostly examples of Eisenmenger's tetralogy or of Fallot's tetralogy. White and Sprague reported the case of an American composer with Fallot's tetralogy who reached his sixtieth year. In the acyanotic group the outlook is far better, but even here Abbott's (1932 and 1936) statistics suggest that there is a high mortality before the fourth decade. *Acyanotic group*

The course in congenital heart disease differs in several respects from that in acquired heart disease. Congestive heart failure is uncommon, and auricular fibrillation is extremely rare, except in the case of defects of the auricular septum with which rheumatic lesions are often associated. In infants asphyxial attacks, cerebral lesions, and pulmonary infections are common causes of death. *Infants*

Later the most important complication is malignant endocarditis (see p. 298), due most often to *Streptococcus viridans*. The infective process may start at a stenosed pulmonary orifice or at the site of a patent ductus arteriosus or of a coarctation of the aorta, in which case it usually spreads to the aortic or pulmonary valves. *Malignant endocarditis*

Pulmonary tuberculosis is stated to be a common complication of congenital heart disease; Peacock cited examples of this association in order to controvert Rokitsky's assertion that congenital cyanosis was incompatible with pulmonary tuberculosis. We have rarely seen pulmonary tuberculosis in subjects of congenital heart disease; it is possible that better living conditions have reduced its incidence. *Pulmonary tuberculosis*

Paradoxical embolism, i.e. embolism of an artery caused by a venous thrombus, may be mentioned as a rare complication of defects of the septa, especially of the interauricular septum. It is said to be commoner when a dextroposed aorta is present, which explains the association of cerebral abscess with Fallot's tetralogy. (For expectation of life in congenital malformations see section 5 on p. 210.) *Paradoxical embolism*
Cerebral abscess

8.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

When signs of heart disease are found before the age of twenty, the diagnosis usually lies between a rheumatic and a congenital lesion. A history of heart trouble dating from birth or infancy will often suggest a congenital aetiology, which will be confirmed by the presence of cyanosis and clubbing or of murmurs which do not correspond to those of mitral or aortic valve lesions. When cyanosis and clubbing occur in adult life, the diagnosis lies between a congenital cardiac defect and acquired sclerosis of the pulmonary arterial tree. Acquired pulmonary arteriosclerosis is almost invariably associated with some degree of fibrosis of the lungs, sometimes syphilitic, and with pulmonary symptoms of long duration. It is usually encountered at a later age than congenital cardiac cyanosis. Occasionally, mitral stenosis with a much dilated pulmonary artery and some cyanosis may simulate a congenital *Diagnosis from rheumatism*
From pulmonary arterio-sclerosis
From mitral stenosis

malformation, but radiography shows characteristic enlargement of the left auricle backwards. The possible coexistence of mitral stenosis with a defect of the interauricular septum should be kept in mind.

Diagnosis of the presence of a congenital cardiac malformation should be followed by identification of the actual lesion. In infants and young children this is often difficult, because the possibilities are numerous and the signs, both clinical and radiological, are often inconclusive. After puberty the possibilities are fewer and the signs more distinctive, with the result that the lesion can usually be identified. The presence of cyanosis, its date of onset, and either its permanent or its transient character will place the case in its particular group. Radiography is invaluable in revealing the presence or absence of dilatation of the pulmonary artery or of abnormal hilar pulsation and in deciding the size and position of the aorta. It provides diagnostic evidence of coarctation of the aorta and right-sided aortic arch. An electrocardiogram determines the presence of right or left ventricular predominance and occasionally shows abnormally large ventricular deflections. The diagnostic signs of each particular lesion will be given in detail (see below).

X-rays

*Electro-
cardiogram*

9.—TREATMENT

Prophylaxis

In view of the predisposition to malignant endocarditis special attention should be directed to the prevention of infection and the elimination of septic foci, as in the teeth and tonsils. The general resistance should be maintained by exposure to sunlight and by an adequate diet. Immunization against scarlet fever may be advisable, and precautions should be taken against pulmonary infections during the winter.

*Training and
education*

Each patient must be trained to a suitable mode of life and occupation, which will vary with the heart lesion present. A special school should be avoided if possible, and an ordinary standard of education should be given. In acyanotic cases few if any restrictions are necessary in childhood, although a sedentary occupation should usually be chosen. In coarctation of the aorta strenuous games or exercise should be forbidden. In the cyanotic group activity must always be greatly restricted and ordinary occupations are rarely possible, but suitable hobbies should be encouraged.

*Acyanotic
group*

*Cyanotic
group*

Palliatives

Palliative treatment may be necessary in cyanotic cases. Venesection may relieve urgent dyspnoea or cerebral seizures, and sedatives are helpful. Oxygen is of little or no value. Heart failure demands the usual measures, such as rest in bed, digitalis, and diuretics.

Pregnancy

Marriage should be discouraged, and pregnancy is generally undesirable, as it is in most cases of organic heart disease. In acyanotic cases pregnancy need not be forbidden in suitable circumstances, but in cyanotic cases it should be prevented as far as possible.

10.—DEXTROCARDIA

620.] This is a condition in which the heart lies mainly in the right half of the thorax. There are several types of congenital dextrocardia:

(i) Dextrocardia with transposition of viscera (*syndromus*,—*situs inversus totalis*; complete heterotaxy).

The heart and all the thoracic and abdominal viscera are completely transposed, but the relations of the various structures to each other

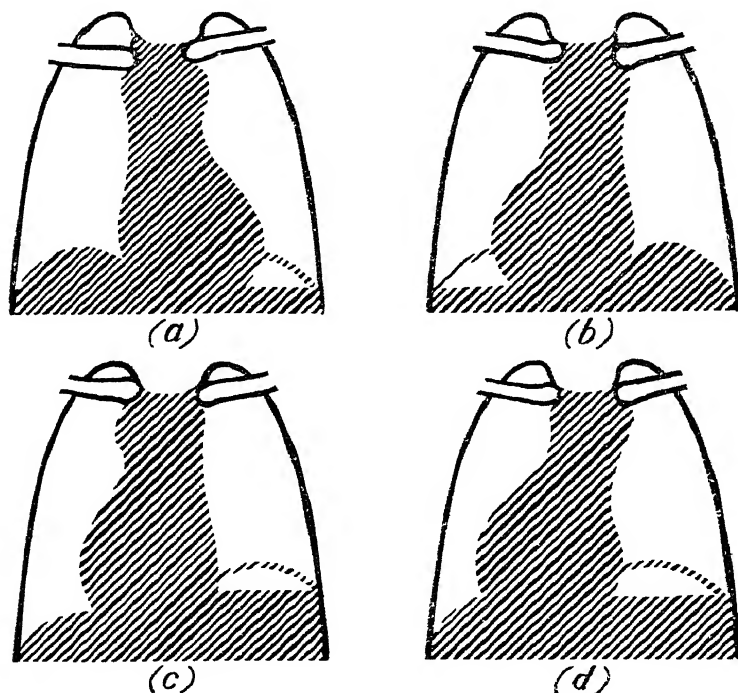


FIG. 26.—Diagrams of radiographs in dextrocardia. (a) Normal. (b) Dextrocardia with transposition of viscera. (c) Isolated dextrocardia with inversion of heart cavities. (d) Isolated dextrocardia without inversion of heart cavities. (After Mandelstam and Reinberg)

are unchanged, with the result that a mirror image of the normal results. In this type of dextrocardia, which is the commonest, the heart is usually normal in other respects. The apex beat is in the fifth right interspace; otherwise the heart appears normal, and there are no symptoms. Radiography shows a mirror image of the heart and thorax. the aortic arch lying on the right side like the heart and the left diaphragm being higher than the right (see Fig. 26, b). A barium meal shows transposition of the stomach and colon. The electrocardio-

X-rays

*Electro-
cardiogram*

(ii) Isolated dextrocardia—i.e. without transposition of viscera.

(a) *Heart cavities inverted (situs inversus cordis)*

X-rays

Electro-
cardiogram

Here the heart is transposed in the same way as in complete transposition, the right ventricle lying in front and the left ventricle behind, forming the apex. In a radiograph the heart is seen on the right, but the aortic arch may be either on the right or on the left side, the latter being slightly the commoner. Thus there may be a true mirror image (see Fig. 26, c), or the aorta may be on the opposite side to the heart (see Fig. 26, d). The electrocardiogram may or may not be typical. Rösler (1930) stated that in isolated dextrocardia there was always some associated cardiac

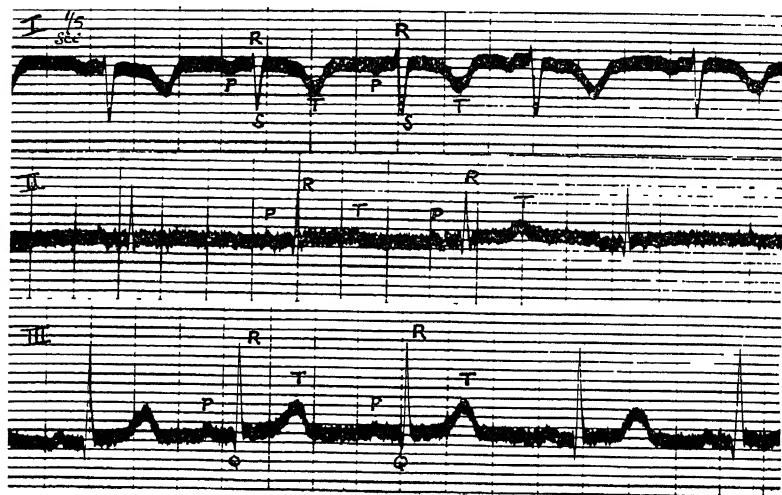


FIG. 27.—Electrocardiogram from case of congenital dextrocardia with transposition of viscera, showing inversion of all deflections in lead I

malformation, either transposition of the great vessels or defective septa. The symptoms and signs are those of the associated lesion, which also decides prognosis. Patients with cyanosis usually die early, but those without serious symptoms may attain adult life.

Prognosis

(b) *Heart cavities not inverted (dextroversio cordis)*

Here, although the heart lies on the right, the heart chambers are not inverted, and therefore there is not a mirror image of the normal. The heart lies as if rotated round a vertical axis from left to right, with the result that the left ventricle becomes anterior and the right ventricle posterior, forming the apex. The aortic arch usually lies on the left side (see Fig. 26, d). Transposition of the great vessels or other malformations are usual in this form of dextrocardia.

(iii) Dextrocardia associated with congenital diaphragmatic hernia.

The heart, which may be perfectly normal, is displaced to the right by a hernial protrusion of the abdominal contents through a congenital aperture in the left diaphragm (see p. 508, and Vol. III, p. 677).

11.—ANOMALIES OF SEMILUNAR CUSPS

621.] There may be a bicuspid valve or a supernumerary cusp. A bicuspid aortic valve may occur alone or with coarctation of the aorta. It is a rare anomaly but important because of the predisposition to malignant endocarditis and to sclerotic changes. The cusps become thickened and often incompetent, and the aorta immediately above the valve may be sclerotic, dilated, or even aneurysmal. The condition does not cause any symptoms before the complications mentioned supervene. A bicuspid pulmonary valve is rare and is sometimes associated with Fallot's tetralogy.

*Bicuspid
aortic valve*

*Bicuspid
pulmonary
valve*

12.—COARCTATION OF THE AORTA

(*Synonyms.*—Stenosis of the aortic arch; isthmus stenosis)

622.] The stenosis occurs distal to the left subclavian artery and adjacent to the insertion of the ductus arteriosus. Two main types are recognized, infantile and adult (Bonnet).

Classification

(1)—Infantile Type

This consists of a diffuse narrowing of the aorta between the left subclavian and the insertion of the ductus arteriosus, which remains patent. It represents a persistence of the foetal state, is usually associated with other congenital anomalies, and is incompatible with adult life. The aortic arch may be absent between the left subclavian and the ductus, blood reaching the descending aorta by way of the ductus.

(2)—Adult Type

This consists of an abrupt and often extreme constriction of the aorta at the site of the ductus arteriosus, which is closed. Complete occlusion of the aorta is occasionally found. The adult type probably develops after birth and has been explained as due to an extension to the aorta of the normal obliterative process which closes the ductus.

According to Evans the incidence of congenital stenosis of the aortic arch in necropsies is one in a thousand. It is commoner in males than in females.

Incidence

Secondary pathological changes

These consist of (i) changes in the heart and proximal aorta due to increased stress; and (ii) development of a collateral circulation by which blood from the ascending aorta circumvents the obstruction and reaches the trunk and lower limbs.

Hypertension proximal to the obstruction leads to hypertrophy and dilatation of the heart and to thickening and degenerative changes in the vessels of the head and upper extremities. The ascending aorta becomes atheromatous and dilated and not uncommonly the site of a

*Changes in
heart and
vessels*

Congenital aneurysms*Embolism**Collateral circulation*

dissecting aneurysm and, eventually, of a rupture. The aortic cusps, often two in number, become thickened and sometimes incompetent. The cerebral arteries are sclerotic and occasionally the seat of minute aneurysms, so-called congenital aneurysms, liable to rupture. An infective process may originate at the site of stenosis as a vegetative aortitis leading to mycotic aneurysm of the aorta or to septic embolism.

Blood reaches the descending aorta by anastomoses which develop between branches of the subclavian arteries and branches of the aorta distal to the stenosis. The principal anastomoses are as follows: (i) between the highest (superior) intercostal branches of the subclavians and the first aortic intercostals within the chest; (ii) between the scapular branches of the subclavians and the upper aortic intercostals on the thoracic wall; and (iii) between the internal mammary arteries and the epigastric branches of the external iliacs in the abdominal wall. These collateral pathways form tortuous and dilated arteries, which may be visible and palpable on the back and abdominal wall and may erode the ribs.

Clinical picture

The condition may remain entirely latent, but symptoms commonly develop during early or middle adult life and occasionally in childhood. The symptoms may be those of increasing cardiac weakness, terminating in congestive failure, or those of hypertension and peripheral vascular disturbance. Palpitation, throbbing of the neck vessels, fullness in the head, and epistaxis are common, and occasionally the lower limbs are cold or weak, but true claudication is exceptional. The innominate and subclavian arteries are dilated and may pulsate excessively at the root of the neck. The radial pulse is full, the artery hard, and the blood-pressure raised, being usually 150 to 200 mm. Hg systolic, sometimes higher. In contrast, the femoral pulse is small and appears to be delayed, or it may be impalpable.

Heart

The heart may remain normal in size, but there is usually moderate enlargement to the left, and the impulse is forcible. A systolic murmur at the base is the rule, and sometimes a late systolic murmur is audible along the borders of the sternum over the dilated internal mammary arteries and also in the interscapular region posteriorly. Signs of a dilated ascending aorta, such as pulsation to the right of the sternum and a ringing second sound, often occur, and in older patients aortic regurgitation is common. The collateral vessels may be seen or palpated in the interscapular region, over the scapulae, or on the anterior abdominal wall. They may vary from time to time and are best seen after exertion. In a few cases the collateral vessels are mainly within the thorax and are not found externally.

*Collateral circulation**X-rays*

X-ray examination may show enlargement of the heart to the left, dilatation of the ascending aorta, absence or abnormality of the aortic knob, and characteristic erosion of the ribs (see Fig. 28). The last named, first described by Rösler (1928), consists of small notches or serrations

in the lower borders of the ribs in their posterior portions; the third to the ninth ribs are most often involved.

Course and prognosis

Many patients are robust and active until they reach adult life, when the symptoms mentioned appear. The majority die between the ages of twenty and forty, either from cardiac failure, which is the commonest cause of death, or suddenly from rupture of the aorta or from cerebral haemorrhage. Malignant aortitis is an occasional fatal complication, the signs and symptoms being those of malignant endocarditis. A few patients escape these dangers and reach an advanced age.

Diagnosis

When hypertension, exaggerated pulsation in the neck, and cardiac hypertrophy are found in a young adult, signs of coarctation should be sought. The positive diagnostic signs are collateral vessels, absence or diminution of the femoral pulse with hypertension in the radials, and notching of the ribs in the radiograph. (See also ARTERIAL DISEASE AND DEGENERATION, Vol. II, p. 62.)

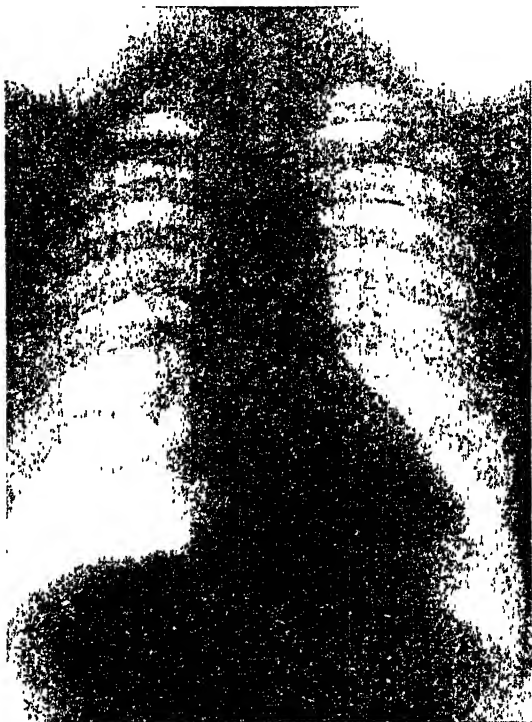


FIG. 23.—Radiograph of coarctation of aorta, showing abnormal aortic knob, slight enlargement of heart to left, and typical serrations of ribs

13.—RIGHT-SIDED AORTIC ARCH

623.] This may be either an isolated anomaly or associated with other congenital defects of the heart, especially with Fallot's tetralogy. The condition is due to the aorta developing from the fourth right primitive arterial arch instead of normally from the fourth left arch.

Definition

Aetiology

In uncomplicated cases the aorta arises normally from the left ventricle;

*Morbid
anatomy*

if combined with Fallot's tetralogy, it arises from both ventricles. In either case the aorta arches over the root of the right lung instead of the left, lying on the right side of the trachea and oesophagus and often passing behind them to reach the left side of the spine. Having crossed the right bronchus, the aorta may turn at once to the left, passing behind the trachea and oesophagus, where its lumen widens to form a



FIG. 29.—Radiograph of right-sided aortic arch, showing barium-filled oesophagus displaced to left by aortic arch. (From *British Journal of Radiology*, 1936)

diverticulum. This diverticulum gives rise to the left subclavian artery, which is thus aberrant and courses behind the trachea and oesophagus to reach the left side.

*Clinical
picture**X-ray:*

Usually no symptoms arise, but in older subjects, when the aorta becomes sclerotic, dysphagia may occur or, rarely, laryngeal palsy. The diagnosis depends on radiography. The aortic knob is seen on the right of the trachea and oesophagus instead of the left, and sometimes the descending aorta is visible on the right side. In the right oblique position a barium swallow demonstrates a characteristic forward displacement of the oesophagus by the aortic diverticulum (see Fig. 29).

14.—AORTIC STENOSIS

624.] Aortic valvular stenosis of inflammatory type, resulting in fusion and deformity of the cusps, may be the result of a foetal endocarditis. The aorta is usually hypoplastic and the left ventricle hypertrophied. *Aetiology*

The subjects of aortic stenosis may be pale, slender, and under-developed, presenting the picture of aortic dwarfism. Cyanosis is absent. *Clinical picture*

The heart is enlarged, and a harsh systolic murmur with accompanying thrill is present at the aortic area; occasionally there is an aortic diastolic murmur. The aortic second sound is diminished or absent. The pulse is small and the blood-pressure low. Radiography shows enlargement of the heart without dilatation of the aorta, which may even appear unduly small. *Heart*
X-rays

Life is short, the average age attained being 3·75 years, with a maximum of 24. Death may be sudden from cardiac failure or from intercurrent disease. *Course and prognosis*

The condition must be distinguished from aortic atresia, in which the valvular stenosis is so severe that the aorta is atresic and the circulation is early diverted through a patent ductus arteriosus into the descending aorta. *Differential diagnosis*

15.—SUBAORTIC STENOSIS

625.] The abnormality arises as the result of failure of atrophy of the bulbus cordis in the left ventricle. The anatomical lesion consists of a fibrous or calcified diaphragm attached to the walls of the aortic conus about a centimetre below the aortic cusps. The lesion may be the seat of malignant endocarditis, which may also involve the aortic cusps. The aorta may be dilated and hypoplastic, and valvular stenosis may be associated. These cases are rare, and Abbott (1932 and 1936) analysed twelve. *Aetiology*

There are no symptoms, the lesion being usually accidentally discovered, perhaps on the development of malignant endocarditis. The physical signs are a systolic thrill and a harsh systolic murmur, of maximum intensity in the second right space. The murmur is conducted along the great vessels and may be heard in the neck and in the axilla. The aortic second sound is well heard. The pulse is small and the blood-pressure low. The apex beat suggests left ventricular hypertrophy (*choc en dôme*), although the heart may not be greatly enlarged. *Clinical picture*
Heart

Radiography shows left ventricular hypertrophy, a small or absent aortic knuckle, and an aorta projecting to the right. The electrocardiogram shows normal or left axis deviation. *X-rays*
Electro-cardiogram

Most patients with subaortic stenosis attain adult life and are usually vigorous and healthy subjects. On routine examination or with the development of infective complications the first evidence of a latent *Prognosis*

lesion may be disclosed. Death may be the result of malignant endocarditis or due to strain. The average age at death is given by Abbott (1932 and 1936) as 22.8 years, with a maximum of 58 years.

*Differential
diagnosis*

Differentiation from valvular stenosis may be difficult, but the presence of the aortic second sound and the absence of dwarfism and of serious symptoms suggest subaortic stenosis.

16.—HEART BLOCK

Aetiology

626.] The origin of the defect appears to be a congenital defect of the bundle of His (see Vol. II, p. 27), and clinically it is particularly associated (59 per cent) with a defect of the interventricular septum. Apart from a developmental origin foetal endomyocarditis and congenital syphilis are possible causes. Even with the most severe septal defects the bundle usually remains intact, partly owing to its development prior to the septum and partly because the common situation of the defect is anterior to the membranous septum. The membranous septum was absent in three necropsies.

*Clinical
picture*

The ventricular rate varies from twenty to ninety, being faster in young subjects, and dissociation may be complete. Adams-Stokes attacks (see Vol. II, p. 29) have occurred. Cyanosis is uncommon and clubbing rare. The symptoms and physical signs are those of the associated defect. Electrocardiographic examination may be essential for diagnosis (see Vol. II, p. 28).

*Course and
prognosis*

The prognosis appears to depend upon the cardiac anomaly rather than upon the heart block. The average age at death is given by Abbott (1932 and 1936) as 7 years, with a maximum of 20.

17.—IDIOPATHIC HYPERTROPHY

Aetiology

627.] Enlargement of the heart due to dilatation and hypertrophy without myocardial disease or other cause, dating from birth or infancy, has been described as idiopathic hypertrophy. In many recorded cases some cause for hypertrophy has been present, e.g. inflammatory myocarditis, aortic obstruction, abnormalities of the coronary vessels, and glycogen disease (see Vol. V, p. 580). The term idiopathic hypertrophy should only be applied to cases in which microscopical examination proves the absence of any change other than hypertrophy.

*Clinical
picture*

The symptoms consist of dyspnoea and cyanosis, caused partly by pressure of the enlarged heart on the lungs and bronchi. The apex beat may be felt in the left axilla; murmurs are absent, but the aortic second sound may be accentuated. The condition is often overlooked until necropsy.

Prognosis

The prognosis is bad, the average age at death being 10 months, with

a maximum of 4 years. Death is due to cardiac failure or pulmonary complications.

18.—PATENT DUCTUS ARTERIOSUS

628.] The ductus arteriosus is normally closed in the first few weeks after birth. It may persist as a sole abnormality, but more often it remains open as part of a more complex anomaly, as for example in valvular atresias. When it exists with aortic or pulmonary atresia, severe cyanosis is present. The cause of persistent patency of the ductus must be sought in some factor which keeps the relative pressures in the aorta and pulmonary artery at the same level as before birth, such as atelectasis, associated cardiac defect, or defects of the wall of the ductus arteriosus. The anatomical types of ductus described by Gerhardt (1867), whether a simple orifice between the aorta and the pulmonary artery, a cylindrical tube, a funnel-shaped tube widest at the aortic end, or an aneurysmal dilatation, may all exert considerable influence on the physical signs. The pulmonary artery is dilated, and there may be hypertrophy of both ventricles. Only patency of the ductus as a sole abnormality is considered here.

Subjects with this lesion have been described as under-developed, slightly built, and anaemic, but 75 per cent of cases examined by Muir and Brown (1932) were of average development. There are not any symptoms other than those of the complications. The physical signs are distinctive.

There is a loud so-called machinery murmur, continuous through systole and diastole and of maximum intensity in the first and second left interspaces near the sternum. The murmur is usually described as being intensified in systole, but phonocardiograms (Routier) show that the maximal vibrations occur at the end of systole and in early diastole. The systolic element is conducted towards the left clavicle and sometimes into the neck. The murmur is accompanied by a thrill, and the pulmonary second sound is always much accentuated. Dilatation of the pulmonary artery gives rise to systolic pulsation in the second left interspace, where the cardiac dullness may be increased (Gerhardt's ribbon dullness). When the ductus arteriosus is of large calibre, it may act as an arteriovenous fistula, allowing a considerable flow from aorta to pulmonary artery. In such cases there will be a compensatory vaso-dilatation, as in aortic reflux, causing a collapsing pulse and arterial throbbing in the neck.

Radiography shows dilatation and increased pulsation of the pulmonary artery (see Fig. 30) and sometimes of the aorta; the heart may be normal or slightly enlarged, and its pulsation is exaggerated. Absence of dilatation of the left auricle distinguishes the picture from that of mitral stenosis, and absence of cyanosis from other congenital lesions. Even in the presence of a typical murmur dilatation of the pulmonary artery may be slight and only evident in the right oblique view, especially

Aetiology

Clinical picture

Heart

Gerhardt's ribbon dullness

X-rays

Differential diagnosis

in children. A widely patent ductus may give a minimal murmur but a typical radiograph. The electrocardiogram is not characteristic and rarely shows right axis deviation.

*Course and
prognosis*
Cyanosis

The lesion may remain completely latent and only be discovered with the onset of complications. Cyanosis may occur in attacks in infants while suckling and may also accompany attacks of dyspnoea and palpitation in older subjects or be present as a terminal event (*cyanose tardive*). The ever-present risk is malignant endocarditis, found in 22·8 per cent of Abbott's (1932 and 1936) cases. The vegetations begin in the pulmonary artery and may extend along the ductus, involving the

Endocarditis

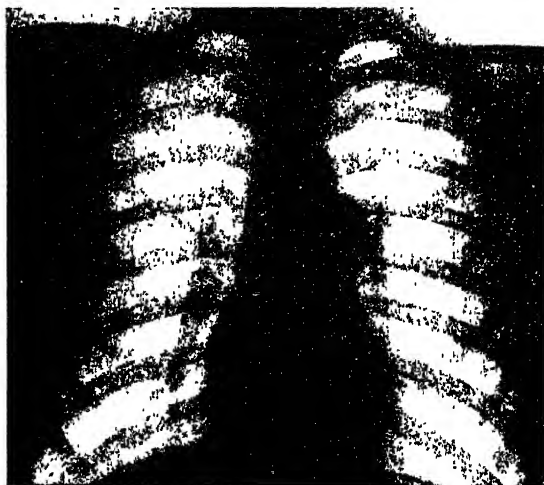


FIG. 30.—Radiograph of patent ductus arteriosus, showing typical dilatation of pulmonary artery. (From *Archives of Disease in Childhood*, 1932)

Epilepsy

aortic valves (Boldero and Bedford; Muir and Brown, 1932; Hamilton and Abbott). Epilepsy occurs often. Rupture of the dilated ductus, paralysis of the left vocal cord, and paradoxical embolism are rare complications. The average age at death is 24, with a maximum of 66 years.

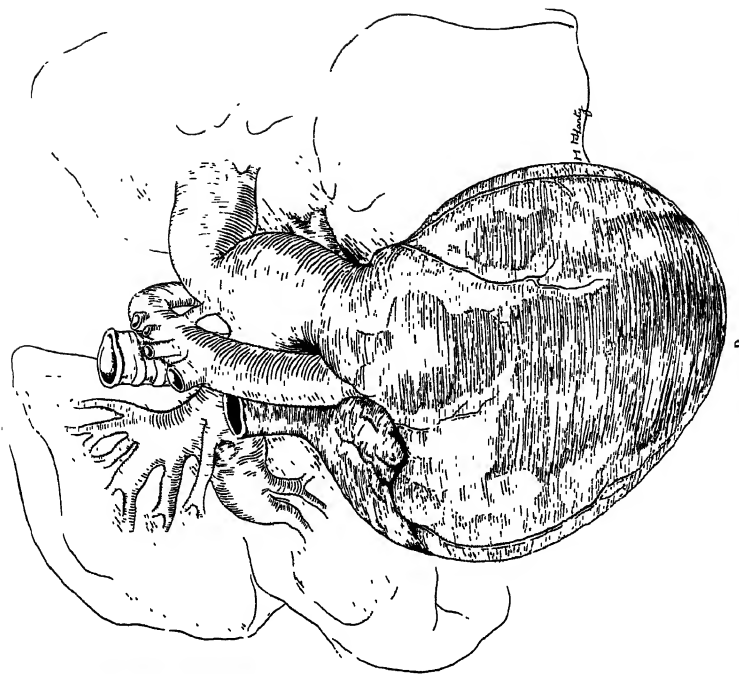
19.—DEFECTS OF THE INTERAURICULAR SEPTUM

Aetiology

629.] Valvular or slit-like patency of the foramen ovale is a common post-mortem finding which need not be regarded as pathological, but apertures in the interauricular septum large enough to allow free communication between the two auricles cause secondary changes in the heart, often leading to heart failure. The aperture may represent a widely patent foramen ovale or a true defect of the septum situated above or below the foramen. The lesion may be isolated or combined



A



B

Defect of interauricular septum in woman aged 35. A. Radiograph showing much enlarged heart and aneurysmal pulmonary artery; its right branch formed a pulsating mass in right lung root. B. Same case; pulmonary artery and main branches dilated, right ventricle much enlarged, and aorta hypoplastic

PLATE II

with other malformations, such as pulmonary stenosis, coarctation of the aorta, or interventricular septal defect. The present description refers to interauricular septal defects without other serious malformations. *Associated malformations*

The secondary pathological changes in the heart consist of great enlargement of the right auricle and ventricle from dilatation and hypertrophy, dilatation of the pulmonary artery and its main branches, which often show atheromatous changes, and occasionally pulmonary incompetence. The left chambers are little affected and the aorta is often hypoplastic. Septal defects are often associated with chronic valvular disease of rheumatic type, especially mitral stenosis (Lutembacher's syndrome). *Secondary changes*

Cardiac symptoms are often absent or delayed until adult life, when they may develop gradually or suddenly during some intercurrent illness. Cyanosis is commonly absent until late; it may occur transiently during exertion, may develop gradually during adult life, or may be only a terminal event. Pallor is quite common. Clubbing is absent or slight, unless there is cyanosis. In about one-third of cases there is poor physical development or even dwarfing (see Vol. IV, p. 304). *Clinical picture*

The pulse is small and the blood-pressure low. In the later stages the pulse may be irregular from auricular fibrillation. The heart is greatly enlarged, the praecordia bulges, and there is diffuse precordial pulsation. Although enlargement involves the right heart chambers, the apex beat is displaced to the left. The most characteristic signs are those due to dilatation of the pulmonary artery, namely, forcible systolic pulsation with diastolic shock, a systolic murmur or even a thrill in the pulmonary area, and a much accentuated pulmonary second sound. A diastolic murmur of pulmonary incompetence is sometimes audible. There may be also the characteristic murmurs of associated mitral stenosis. A systolic murmur and thrill, sometimes extending into diastole, situated behind the mid-sternum, has been described as due to the septal defect, but it is difficult to exclude pulmonary dilatation as the cause of such a murmur. In a few cases murmurs are absent. *Cyanosis*
Blood-pressure
Heart

The radiograph is characteristic and consists of great enlargement of the heart, which is globular or of the *cœur en sabot* shape, dilatation of the pulmonary artery and its branches often attaining aneurysmal proportions, and a small aorta. The right pulmonary artery forms a large pulsating shadow in the right lung root which has been wrongly diagnosed as a tumour (see Plate II). The electrocardiogram shows right axis deviation, often with inversion of the T-waves in leads II and III, and sometimes the QRS complex is widened, suggesting bundle-branch block (see Fig. 31). *X-rays*
Electro-cardiogram

The average age at death in Roesler's 62 cases was 36; the youngest subject was 11 months and the oldest 75 years. During childhood and early adult life symptoms may be slight or absent, and many subjects are capable of normal physical activities and may bear children *Course and prognosis*

without difficulty, but some are delicate and have to lead restricted lives.

Cyanosis and dyspnoea may develop gradually or suddenly during some intercurrent illness. Cardiac failure, often with auricular fibrillation, is the usual cause of death. Unlike most other congenital lesions, auricular septal defects seldom predispose to malignant endocarditis, and pulmonary tuberculosis is rare. Paradoxical embolism is an occasional complication; clot detached from a venous thrombosis may pass through the septal defect and lodge in the systemic arteries.

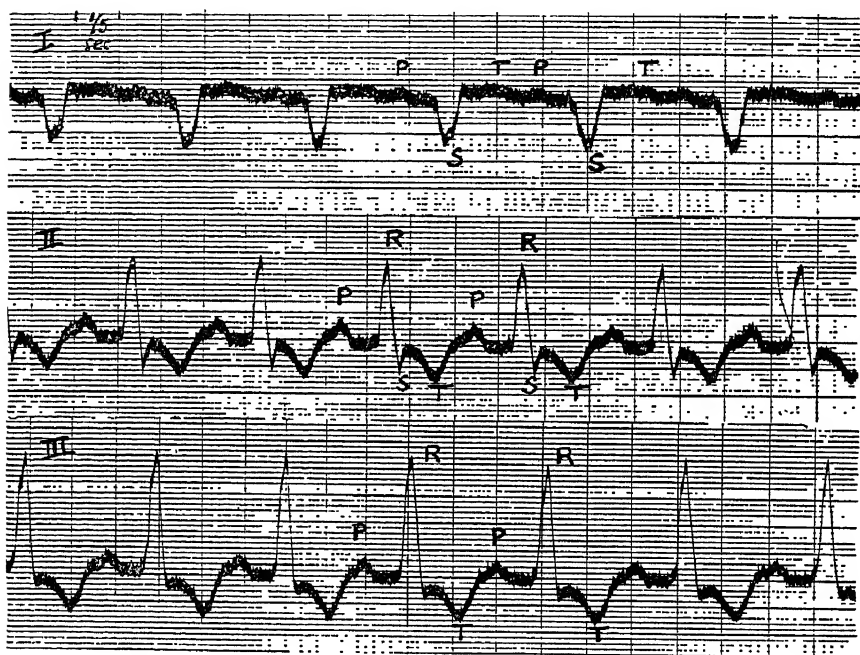


FIG. 31.—Electrocardiogram from a case of patent interauricular septum (necropsy control) showing right axis deviation, with widened RS deflections and inversion of T-waves in leads II and III

al The characteristic radiograph of aneurysmal dilatation of the pulmonary artery and its branches, with gross enlargement of the heart and a small aorta, should suggest auricular septal defect. Other congenital lesions causing pulmonary dilatation can usually be excluded by the absence of their typical murmurs. Of acquired heart lesions mitral stenosis and chronic lung disease with pulmonary arteriosclerosis may give a somewhat similar radiograph; in mitral stenosis the murmurs, rheumatic history, and enlarged left auricle are points of distinction, although auricular septal defect may co-exist. In acquired pulmonary arteriosclerosis chronic lung disease is usually present.

20.—ISOLATED INTERVENTRICULAR SEPTAL DEFECTS

(*Synonym.*—*Maladie de Roger*)

630.] Uncomplicated interventricular septal defects arise towards the end of the eighth week of intra-uterine life and are situated anterior to the membranous septum. Small in size and encircled by fibrous tissue, they may be gradually obliterated with disappearance of physical signs (Parkes Weber; French). Cicatricial tissue derived from the defect may involve an aortic cusp and lead to its deformity with aortic incompetence. *Aetiology*

The only symptoms are those of complications. Cyanosis on exertion has been mentioned by Perry and *cyanose tardive* by others. Permanent cyanosis excludes the pure abnormality. The physical signs are those described by Roger and consist of a mesocardial systolic murmur and often a thrill of maximum intensity in the third and fourth left spaces. The murmur has a peculiar harsh quality and is conducted with diminishing intensity towards the periphery. It may be heard in the back. *Clinical picture*
Cyanosis
Heart

There is no characteristic radiograph, although a globular heart has been described, and the pulmonary artery is often slightly dilated. *X-rays*

Subjects with this lesion are usually strong and healthy and able to lead active lives not subject to any restrictions. The lesion is probably much more common than is generally supposed; many cases remain entirely latent until the onset of complications, and many are interpreted as of rheumatic aetiology. Malignant endocarditis may involve the margins of the defect and that part of the wall of the right ventricle on which the abnormal shunt impinges. Congenital heart-block (see p. 222) has been most often associated with this condition (Yater; Lampard). Abbott (1932 and 1936) found the average age at death to be 14.5, with a maximum age of 49 years. *Course and prognosis*

21.—PULMONARY STENOSIS WITH CLOSED INTERVENTRICULAR SEPTUM

631.] This type of stenosis, developing after the septa have closed, is often inflammatory in origin. The stenosis is usually valvular, the cusps being fused into a diaphragm with a small aperture, but it may be subvalvular or between the conus arteriosus and the main cavity of the ventricle. The pulmonary tract may be narrowed as a whole or completely occluded at some point (atresia). The foramen ovale is usually patent and sometimes the ductus, especially in pulmonary atresia. The pulmonary artery may be either dilated or hypoplastic, and similarly the conus arteriosus may be either dilated or narrowed (see Fig. 32). *Aetiology*

*Clinical
picture*

Cyanosis may be absent or slight or only develop late, and it is less severe than in Fallot's tetralogy. Clubbing is slight or absent, corresponding to the degree of cyanosis.

Heart

The signs consist of a harsh systolic murmur and thrill in the pulmonary area. The pulmonary second sound is diminished or absent in some cases but may be normal or accentuated when the stenosis does not involve the valves. Radiography often shows a prominent pulmonary arc, which may be due to a dilated conus (Usumoto). The electrocardiogram often shows right axis deviation (see Fig. 33).

X-rays

*Electro-
cardiogram*

Prognosis

FIG. 32.—Stenosis of conus arteriosus of right ventricle below pulmonary cusps, with malignant endocarditis at site of stenosis. Pulmonary artery much dilated beyond stenosis; aorta slightly constricted at isthmus

appear, together with increasing dyspnoea and incapacity. The duration of life is longer than in Fallot's tetralogy; Abbott's (1932 and 1936)

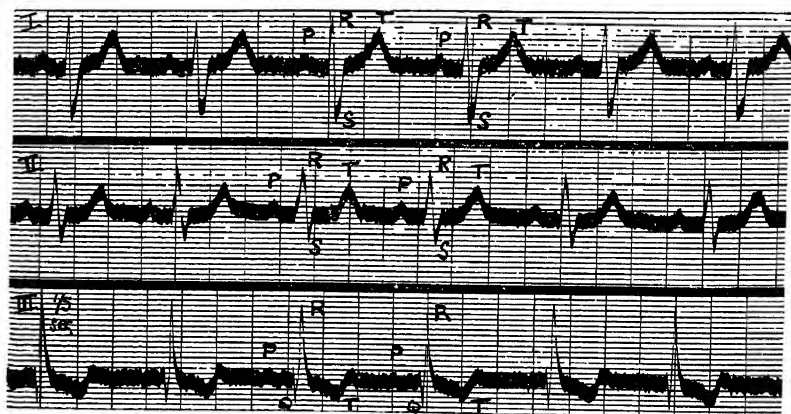


FIG. 33.—Electrocardiogram from a case of simple pulmonary stenosis showing right axis deviation

statistics show a maximum age of 45 years. average age of 22. when all septa are closed, and a maximum age of 57 years. average age 18. with patent foramen ovale. With pulmonary atresia the duration of life is shorter, the average being less than two years. The cause of death is commonly malignant endocarditis, pulmonary tuberculosis. or intercurrent disease.

22.—FALLOT'S TETRALOGY

(*Synonym.*—Pulmonary stenosis with patent ventricular septum)

632.] The tetralogy consists of pulmonary or conus stenosis. inter- *Definition:*
ventricular septal defect, dextroposition of the aorta, which lies astride

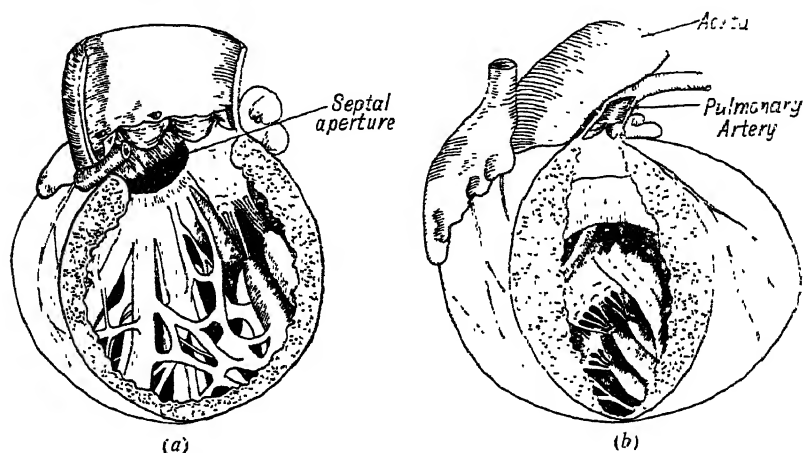


FIG. 34.—Fallot's tetralogy. (a) Left ventricle opened, showing defect of septum. (b) Right ventricle opened, showing hypoplasia of pulmonary artery and large aorta

the septal defect, and great hypertrophy of the right ventricle, without much dilatation. The pulmonary stenosis may consist of hypoplasia of the whole pulmonary tract or may involve the valves or the infundibulum or both. The pulmonary artery is of small calibre and thin-walled. The aorta is large and displaced to the right and communicates with both ventricles above the septal defect (see Fig. 34). Although the right ventricle is hypertrophied, there is little dilatation, and the heart is not much enlarged. Other cardiac malformations may be associated, especially right-sided aortic arch and a patent foramen ovale.

Deep cyanosis from birth is the rule, although there may be exceptions, *Clinical picture*
and clubbing is always present in those that survive long enough. The pulse is regular and small, and the blood-pressure tends to be low. Enlargement of the heart is slight or absent. A systolic murmur is *Heart*
heard in the third left space, and it may be transmitted to the neck or carotid vessels; it is usually less intense than in pulmonary stenosis

with closed ventricular septum, and occasionally it is faint or absent. A systolic thrill at the pulmonary area is common but not constant, and the pulmonary second sound is usually diminished or absent.

X-rays

The radiograph is characteristic and shows a *cœur en sabot* configuration without appreciable enlargement of the heart transversely. There is not any dilatation of the pulmonary artery, and often a noticeable concavity is present between the vascular pedicle and the heart proper

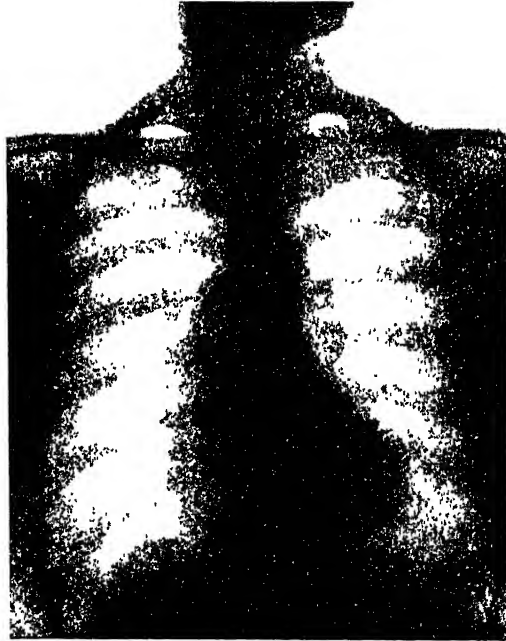


FIG. 35.—Radiograph of Fallot's tetralogy, showing *cœur en sabot*, concavity in region of pulmonary artery, and aorta projecting to right

*Electro-
cardiogram*

on the left side. The aorta may appear large and extend abnormally to the right (see Fig. 35). The electrocardiogram shows well marked right axis deviation.

*Course and
prognosis*

Life is usually short, and the average age at death is given by Abbott (1932 and 1936) as 12 years. A few reach 20 to 30 years, and the highest recorded age reached is 59, that of an American musician reported by White and Sprague. Those affected are usually invalids and incapacitated from work. Death is most often due to pulmonary tuberculosis, malignant endocarditis, or intercurrent disease.

23.—EISENMENGER'S TETRALOGY

Definition

633.] This combination of congenital defects, first clearly described by Eisenmenger in 1897, is rarer than Fallot's tetralogy and consists of a

defect of the ventricular septum, dextroposition of the aorta astride the septal defect and communicating with both ventricles, dilatation of the pulmonary artery or conus or both, and enlargement of the right ventricle.

Moderate or deep cyanosis is the rule and clubbing of the fingers proportional to the cyanosis. Clinical examination reveals a harsh mesocardial systolic murmur, not transmitted to the neck, sometimes accompanied by a thrill, and an accentuated pulmonary second sound. Radiography shows a large pulmonary arc, formed either by the artery or by the conus, which differentiates it from Fallot's tetralogy, in which the pulmonary artery is hypoplastic. *Clinical picture*

Eisenmenger's patient died at the age of 32, and Abbott's (1932 and 1936) statistics show an average duration of life of 14 years, the maximum being 59 years. The degree of disability may be less than in the other malformations causing cyanosis. Death may be due to heart failure, malignant endocarditis, or intercurrent disease. *Course and prognosis*

24.—TRANSPOSITION OF THE GREAT VESSELS

634.] Transposition of the great vessels may be complete, the aorta arising from the right ventricle and the pulmonary artery from the left without other cardiac abnormality. It has been explained by Spitzer on phylogenetic grounds as an effect of lack of torsion of the primitive cardiac tube leading to a persistence of the right repulian aorta, the transposed vessel corresponding to this structure which normally disappears in the human heart. *Aetiology*

In 'corrected' transposition the aorta and pulmonary artery, although transposed, communicate with their proper ventricles. The aorta, lying in front of the pulmonary artery, arises from a small anterior ventricle, which communicates with the left auricle by a bicuspid valve. The pulmonary artery opens into a large posterior ventricle, which forms the apex of the heart and communicates with the right auricle by a tricuspid valve. A large defect of the interventricular septum may accompany both types. *'Corrected' transposition*

In complete transposition extreme cyanosis exists from birth and life is brief. The effects of a grave handicap to the circulation may be mitigated by an interventricular septal defect and a patent ductus arteriosus, with consequent lessening of cyanosis and prolongation of life. In 'corrected' transposition cyanosis is slight or absent entirely. *Clinical picture*

It is impossible to diagnose the condition with certainty during life.

In complete forms life is generally brief, with an average of 6 months. In 'corrected' transposition the average age at death is 11 years, with an extreme of 24 years (Abbott, 1932 and 1936). *Course and prognosis*

25.—TRICUSPID ATRESIA

635.] Tricuspid atresia is always associated with an interauricular septal defect and often with a defect of the interventricular septum. The *Aetiology*

right ventricle is extremely small and aplastic, and there may be pulmonary atresia. The ductus arteriosus remains patent. This group of abnormalities constitutes a functional cor biatriatum triloculare.

Clinical picture

Cyanosis is present from birth and gradually deepens in intensity. Murmurs are usually absent, unless there is an associated interventricular septal defect.

X-rays

Radiography shows a large left ventricle, a dilated right auricle, and a small vascular pedicle.

Left axis deviation is present.

*Electrocardiogram
Diagnosis*

The combination of cyanosis with left axis deviation in the electrocardiogram is sufficiently characteristic of this defect to enable a correct diagnosis to be made.

Prognosis

Life is usually not protracted, the average age at death being 5 years. Life may be more prolonged in those cases in which there is transposition of the vessels.

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II.—RHEUMATIC HEART DISEASE IN CHILDREN

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1.—INTRODUCTION

(*Synonyms.*—Rheumatic carditis; rheumatic myocarditis, endocarditis,
and pericarditis)

636.] A description of rheumatic heart disease in children is an account of an infection invading the heart through the coronary arteries and tending to become generalized throughout its substance. Although for descriptive purposes we may speak of rheumatic myocarditis, endocarditis, or pericarditis, such terms seldom if ever accurately describe

the pathological or even clinical condition present. Wide-spread changes in the heart are the rule; severe disease is not confined to the myocardium or endocardium as it is in diphtheria or malignant endocarditis respectively. On the contrary, if the myocardium is at all severely affected, the endocardium will be invaded; when the valves are attacked, the myocardium will not escape; and, if pericarditis develops, both the heart-muscle and the endocardium will assuredly, sooner or later, be severely infected. For these reasons rheumatic heart disease is most accurately described as rheumatic 'carditis'. *Rheumatic carditis*

To attempt a definition of rheumatic heart disease is unnecessary: it is only a part of the general infection known as acute rheumatic infection. A bacteriological definition would probably still be unacceptable. The streptococcal hypothesis of the origin of acute rheumatism, advanced by F. J. Poynton and A. Paine in 1900, has not yet won general acceptance in spite of the strong evidence in its favour. Nevertheless rheumatic carditis is a very clear-cut entity: its morbid anatomy, especially its histopathology, is its most distinguishing feature; and clinically it conforms so closely to type that it can usually be recognized even when evidence of general rheumatic infection is equivocal or absent.

2.—AETIOLOGY

The controversial subject of the bacteriological cause of acute rheumatism and its attendant carditis will not be discussed here. The whole subject has been studied in such detail pathologically and clinically that the description of rheumatic heart disease need suffer little if the question of its exact bacteriological cause is left open. It is assumed here that the infecting agent reaches the heart through the coronary arteries and there sets up its characteristic tissue-changes. That a name is not given to the infecting agent matters little: still less, it is hoped, does it matter that I believe, in spite of one or two difficulties remaining, that the infecting agent is a non-pyogenic streptococcus of the *S. viridans* type, which is a normal inhabitant of the alimentary tract. See also RHEUMATIC INFECTION, ACUTE. *Path of infecting organisms*

The general aetiological factors in the production of rheumatic heart disease are governed by those of acute rheumatic infection. It is therefore unnecessary to discuss in detail such factors as age, sex, heredity, social environment, and tonsillar infections. The position may be summed up by the statement that rheumatic heart disease in children is particularly common in the children of the poor, living in industrial towns, attending elementary schools under compulsion, and suffering from infected tonsils. *Rheumatism*

Given rheumatic infection, some factors predispose further towards cardiac rheumatism. As might be expected, the more severe the rheumatic attack and, within the limits of the age incidence of juvenile rheumatism, the younger the child, the more likely is the heart to be *Rheumatic heart disease*

Environmental factors

affected. Environmental factors are of such importance in the production of juvenile rheumatism that it is hard to escape the conclusion that they play a part in determining the severity of the complaint and thus the likelihood of cardiac disease. These factors are not so much the concomitants of great poverty, such as squalor, underfeeding, and overcrowding, as those of comparative poverty. Housing is important; the cold damp jerry-built house, cheaply built on a cheap damp site, is a probable danger; and rheumatic heart disease is admittedly common among children dwelling in basements. Chronic tonsillar infection predisposes strongly not only to juvenile rheumatism but also to rheumatic heart disease; this is shown by the fact that in the acute rheumatism of tonsillectomized children the incidence of carditis is far lower than in those with infected tonsils (Miller).

*Chronic tonsillar infection**Nature of early attacks*

The early attacks in a series of rheumatic attacks are those which seem to determine if the heart is to be involved or not. Thus, if the heart has been spared in the first two or three attacks, it is unlikely that it will become affected in later ones. On the other hand, if the heart has been severely damaged in the early rheumatic attacks, it is unlikely to be spared in subsequent attacks; indeed it will probably bear the brunt of each recrudescence.

Absence of rheumatic symptoms

There remain those cases of heart disease conforming to the rheumatic type but without any history of rheumatic symptoms. In these the rheumatism may have been so mild as to be forgotten, overlooked, or misinterpreted, but there seems to be no doubt that rheumatic carditis may be the only recognizable manifestation of rheumatic infection. Such cases are commoner in adolescents and adults than in children and most commonly show mitral stenosis as the cardiac lesion. In such instances buried septic tonsils are the rule, with or without a history of sore-throats.

Incidence in elementary school children

Figures for the incidence of rheumatic carditis among children attending elementary schools in industrial towns are usually given very roughly as 1 per cent of entrants and 3 (2.5 to over 5) per cent for 'leavers'. It is to be hoped that such figures should now call for modification, but it must be understood that they never represented the incidence of the disease in the general juvenile population of the country. Allowances must be made for the facts that in the elementary school children in rural districts, and even in residential towns, the disease is much less common than in the children living in industrial towns; and that in children of the well-to-do classes rheumatic heart disease is almost a rarity.

Social class incidence

Juvenile rheumatism and its carditis show a very definite class incidence; the upper limit of the rheumatic stratum of the child population appears to run just above the class that attends the elementary State schools under compulsion. This is well shown by the figures kindly supplied by Pearse Williams from the Regent Street Polytechnic Secondary School. Comparing the scholarship boys from the elementary schools with the fee-paying boys, the percentages of rheumatic heart

disease in the two groups were 2.57 and 0.98 respectively, in spite of the fact that the scholarship boys must to some extent be selected physically as well as intellectually.

It is more than probable that such figures as are given here now require considerable modification, especially as regards London. For very many years there has been a gradual diminution in the severity of rheumatic infection with probably a diminution in its incidence; rheumatic hyperpyrexia has virtually disappeared, and the old-fashioned case of rheumatic fever is hardly ever seen. It cannot be doubted that a reduction in the severity of acute rheumatism would cause a diminution of the amount of heart disease in children: first, the most severe types of carditis would diminish in incidence; secondly, the more ordinary heart cases would become less common; this seems to be what is happening. Acute pericarditis, the most severe acute manifestation of cardiac rheumatism, is far less common than it was. In the period 1882-93 out of every 100 admissions to St. Bartholomew's Hospital for acute rheumatism from 12 to 15 showed acute pericarditis (Church); by 1910 this figure had fallen to below 5; and now it can hardly be doubted that, even in a children's hospital, the percentage of rheumatic in-patients with acute pericarditis would be well below this figure. Further, experience in London suggests that in recent years there has been a notable diminution in the more ordinary cases of juvenile rheumatism and rheumatic carditis. Each winter for the last few years (preceding 1937) corresponded with what would previously have been regarded as a very mild rheumatic season, and hope is beginning to dawn that this improved state of affairs has come to stay.

Decrease in incidence

3.—PATHOGENESIS AND MORBID ANATOMY

Rheumatic carditis is the result of an infection attacking the heart in a series of doses through the coronary arteries; but it is noteworthy that these arteries themselves are not attacked sufficiently to interfere with their function, and there is thus every chance for compensatory changes in the heart-muscle to be satisfactorily established, once the activity of the infection has died down. The infective agent enters the blood-stream in most cases through the nasopharynx and, having arrived in the tissues, sets up peculiar lesions with the same histology in the endocardium, myocardium, and subcutaneous nodes. These tissue reactions are so peculiar to rheumatic infection that they afford strong evidence in support of the view that the infective cause of the disease, at all events when acting in the human body, is a specific agent. The histopathology of rheumatic carditis was extensively studied by C. F. Coombs.

Rheumatic tissue reactions

(1)—Myocardium

The myocardium shows macroscopically changes due to inflammation and toxæmia, but the histological changes are of special interest. These

Myocarditis

Microscopical appearances show three sets of features: (i) the peculiar proliferative tissue-reaction in the stroma set up by the infecting agent; these areas, seen mainly close to the arterioles, consist of multinucleated cells, the submiliary nodules of Aschoff; (ii) toxic parenchymatous changes, consisting of fatty degeneration of the muscle cells and most marked close to the endocardium and pericardium and in the papillary muscles; and (iii) cicatricial healing changes.

(2)—Endocardium

Endocarditis Recent rheumatic endocarditis is shown by characteristic vegetations on the valves, the peculiar tissue response to the rheumatic infecting agent. There will also be a variable amount of inflammatory swelling of the valve and the fibrotic healing processes resulting from previous valvulitis. These changes are also marked in the chordae tendineae. The mitral valve is the first attacked, possibly because it is the largest, and the bead-like vegetations occur in a row close to the free edge of the valve-segments. If a second valve is attacked it will be the aortic, probably by direct spread from the mitral valve. The inflammatory foci here are seen spreading from the neighbourhood of the corpora Arantii. The tricuspid valve is involved in a fair proportion of fatal cases of rheumatic carditis.

(3)—Pericardium

Pericarditis Areas of congestion and roughening of the serous surface of the pericardium are seen earliest at the base of the heart and may extend universally within and outside the pericardium, which may become much thickened and show nodes similar to the subcutaneous nodes found in the neighbourhood of joints in acute rheumatism. The pericardial fluid may be clear, flaked with lymph, or blood-stained. *Pleurisy* may be present at the base of the lung, usually on the left side. *Pericarditis* commonly, but by no means constantly, sets up adhesions, internal and external.

4.—CLINICAL PICTURE

Onset Rheumatic carditis usually develops on set lines. With active rheumatic infection the myocardium is constantly affected. In attacks of any severity (in-patient type) both myocardium and valves are usually involved. Pericarditis denotes carditis of more than usual severity. The various modes of onset, common and rare, merit attention.

Sore-throat and fever (i) Most commonly a first or early attack of carditis develops after sore-throat and is associated with fever and clear evidence of rheumatic infection. Both myocarditis and endocarditis are present. The heart is enlarged, and a mitral and perhaps other murmurs are audible.

Pericarditis (ii) Acute pericarditis may be added, thus completing the picture of pancarditis. The three modes of onset of this are given on page 261.

(iii) In the mildest or ambulatory cases it may be difficult to recognize

the presence of rheumatic infection and still more the beginnings of myocarditis (see below); but after weeks or months an attack of obvious carditis may develop. *Mildest cases*

(iv) Again, in ambulatory cases persistent tachycardia may be the only cardiac abnormality. Simple tachycardia is not uncommon in children, and only a small minority of such cases have any association with rheumatism. In such the attack of carditis may develop after many weeks of unexplained tachycardia. *Tachycardia*

(v) Valvular disease is sometimes found in a child in whom symptoms of rheumatism cannot be traced. Usually, however, there is clear evidence, either by history or inspection, of the presence of septic tonsils. *Chronic tonsillar sepsis*

(vi) Very rarely the first sign of rheumatic carditis is the sudden onset of complete heart-block in a supposedly healthy child. An attack of febrile rheumatism follows in a week or ten days. This sequence of events no doubt means that the earliest myocardial lesions have developed in the conducting tissues. *Heart-block*

The symptoms of rheumatic heart disease in children may be described under two headings: general symptoms due to the presence of rheumatic infection, and cardiac manifestations due to the involvement of the heart. *Symptoms*

The child with any degree of active rheumatism is always physically subnormal, with wasting, pallor, fatigue, loss of appetite, and some shortness of breath. On the nervous side it is excitable, emotional, and unstable, and tends to suffer from various so-called functional disorders, such as insomnia, tics, enuresis, night-terrors, and sleep-walking. The temperature is often persistently, though only slightly, raised in the evenings; if the rheumatic infection becomes more severe, the temperature rises higher and the general symptoms of juvenile rheumatism appear, together with clear evidence of cardiac involvement. *General*

In dealing with the cardiac symptoms of rheumatic carditis in children two points of fundamental importance require emphasis. First, with the exception of precordial pain due to pericardial friction, all the cardiac symptoms are due to involvement of the myocardium. As the heart-muscle becomes more and more actively diseased, the myocardium fails to maintain the circulation efficiently, at first during exertion, but later when the child is at rest. Secondly, the onset of cardiac symptoms in a rheumatic child invariably denotes fresh active carditis and never a purely mechanical failure from an old and entirely quiescent lesion of the myocardium. This rule holds even in advanced heart disease in children, and indeed is more applicable to rheumatic heart disease in adults than is perhaps recognized. *Cardiac*

Cases of active rheumatic carditis in children can be fairly easily classified into four common clinical groups according to their severity; their cardiac symptoms may be most usefully described under each type.

(i) Mildest (ambulatory) cases. Cardiac symptoms of the lowest grade *Mildest cases*

of severity will be seen in two groups of children: first, physically sub-normal children (described above) in whom rheumatism is the suspected rather than the assured cause of ill-health; and, secondly, known rheumatic children in whom the question arises whether active carditis is present or not. In these the cardiac symptoms are no more than a feeling of fatigue and some shortness of breath on exertion, with perhaps mild vasomotor symptoms. To these symptoms may be added the signs of slight cardiac dilatation; increase of the pulse-rate persisting during sleep; an evening rise of temperature; and mild rheumatic symptoms, such as muscular pains. From the preventive point of view this group showing very early rheumatism and carditis is of great importance.

Ordinary cases

(ii) Carditis of ordinary grade. In the ordinary in-patient type of rheumatic carditis the child looks ill, pale, and thin. The heart shows the changes proper to the cardiac lesion present; the pulse-rate is raised to between 100 and 120 and is well above normal during sleep. The respiration-rate is somewhat raised, but true dyspnoea, either persistent or paroxysmal, is absent, and the child lies comfortably on one or two pillows. There is fever up to 102° F., but under treatment the morning temperature soon reaches normal, although a slight evening rise is apt to persist. Signs of congestive heart failure are usually absent, and there is very little cyanosis. Neither the liver nor the spleen is enlarged, and oedema is absent. This very common type of active rheumatic carditis may be accompanied by rheumatic arthritis, chorea, and, occasionally, subcutaneous nodes; but in many instances the only evidence of active rheumatic infection is a history of a recent cold or sore-throat, and it is clear that the activity of the infection is focused on the heart.

Severe acute carditis

(iii) Severe acute carditis. When there is severe active carditis, especially when it has developed rapidly, the child quickly becomes extremely ill, and cardiac embarrassment is very evident. The child is intensely pale, turning at times a distressing ashen colour. The lips tend to be bluish. The dyspnoea is urgent, and the child cannot rest unless well propped up in bed. Attacks of cardiac asthma may supervene, especially at night. The pulse is rapid (120 and over), feeble, and running. The temperature is probably between 102° and 104° F. and tends to be specially high if pericarditis is present. Precordial pain or discomfort may develop. As a rule the child is restless, unable to get comfortable or to sleep, and delirium at night is common. Cardiac vomiting may be troublesome. The liver may be painful but is more often only tender, the degree of discomfort depending not only on the size of the liver but also on the rapidity with which it has become enlarged. Some oedema of the lungs may be present, but oedema elsewhere is uncommon.

This dangerous type of carditis is often seen in association with acute pericarditis and indeed is sometimes spoken of as the clinical picture of that condition; but it is the severity of the myocardial infection and failure that is responsible for the cardiac symptoms. The other manifestations of rheumatic infection likely to be seen in association with

severe acute carditis are arthritis and subcutaneous nodes. Chorea may precede it, but, while the heart is in such urgent distress, the choreic symptoms, as a rule, subside.

(iv) Acute carditis in the cardiac cripple. When fresh carditis develops in a heart previously crippled by rheumatic infection, it tends to come on somewhat insidiously, and the symptoms correspond, even in fatal cases, more closely to the congestive heart failure of adults than to the acute symptoms of severe carditis as given above. Thus there will be cyanosis, orthopnoea, enlargement of the liver, and oedema of the lungs with perhaps ascites and oedema of the back or legs. Auricular flutter and fibrillation are rare in childhood.

*Acute
carditis in
cardiac
cripple*

In such cases clinical evidence of fresh activity of the rheumatic infection may be difficult to find; but, as a rule, there is a history of a recent cold or sore-throat, and the temperature is raised. Subcutaneous nodes should be carefully sought. On the other hand, necropsy invariably shows fresh active carditis, and thus it may be concluded that, even in the really crippled heart in which old damage and mechanical embarrassment are at a maximum, renewed active cardiac rheumatism is essential to determine the onset of cardiac failure.

(1)—Myocarditis

Damage to the myocardium is constantly present in all forms of rheumatic carditis, from the slightest to the most severe, and it is upon the myocardial factor that the symptoms and dangers of rheumatic heart disease in children depend, even when the valves and the pericardium are involved. The symptoms, therefore, of rheumatic myocarditis are those of carditis (see p. 239) according to the various grades of the severity of the myocardial infection. The physical signs are those of dilatation of the heart. The deep cardiac dullness is increased to right and left, the apex beat is displaced outside the mid-clavicular line, the pulse is rapid and soft, and its rate remains raised even during sleep. As the left heart dilates, the apical first sound should become shortened, but usually by this time a mitral systolic murmur has developed. (See also MYOCARDIUM DISEASES, p. 277.)

Incidence

Symptoms

Signs

(2)—Endocarditis

Endocarditis is added to myocarditis in the great majority of in-patient cases of rheumatic carditis in children, and of the valves of the heart the mitral is always the first to be attacked. If a second valve is involved, it is the aortic. In severe carditis of the cardiac cripple type the tricuspid valve may also be attacked, although clinical evidence of this is seldom found in children. The pulmonary valve is not affected in rheumatic carditis.

Incidence

Mitral incompetence is the first valvular lesion to develop in cases of rheumatic carditis. In its establishment there are two factors, myocardial and endocardial. The inflammation of the cardiac muscle produces stretching of the mitral ring; this is probably the chief factor in the

*Mitral
regurgitation*

production of the valvular leakage. The endocardial inflammation towards the free edge of the valve appears at first to help more in the production of the murmur than of the actual incompetence, although doubtless, as healing and scarring of the valve occur, this factor tends to maintain the defect. The influence of the valvulitis on the production of the mitral murmur is suggested by the fact that in the most severe forms of diphtheritic dilatation of the left ventricle due to a pure myocarditis without valvulitis (see Vol. IV, p. 84) a systolic bruit is very exceptional, whereas in rheumatic carditis with its associated endocarditis it is the rule. The importance of the myocardial factor in the production of rheumatic mitral regurgitation explains how it is that many cases of pure mitral incompetence clear up in the course of a few years.

Signs

The characteristic physical sign of mitral incompetence is the addition of an apical systolic bruit to the signs of cardiac enlargement. This is conducted towards the left axilla and may be audible at the angle of the left scapula, and in well marked cases may be accompanied by a systolic thrill; although exceptional, this is the commonest thrill to be felt in acquired heart disease in children.

The development of the bruit is preceded by dilatation of the left ventricle, and in some instances it only makes its appearance as the activity of the carditis diminishes and the heart's action becomes slower and stronger. More often the murmur is only intensified at this stage.

Mitral stenosis

Fully developed mitral stenosis with its characteristic signs is rare during childhood. For this there are several reasons. First, for the establishment of true stenosis there must be previous rheumatic inflammation throughout the whole substance of the valve from free to attached borders; and for this to reach a degree which will be followed by universal thickening and fibrosis of the valve usually requires either repeated attacks of endocarditis or a long subacute infection of the valve. Further, time must elapse for the recovery of the myocardium so that the mitral ring will not be so much stretched as to preclude stenosis of the orifice by the damaged valve.

Apical mid-diastolic murmur

Established mitral stenosis being rare in children, the question arises if it is possible to recognize in them the preliminary inflammatory and healing stages which will later end in true stenosis. Many hold that the apical mid-diastolic murmur indicates these preliminary stages. This murmur is heard over a small area immediately internal to the apex beat; it follows the second apical sound, from which it is separated by a very brief interval of time. At its earliest appearance this abnormal apical diastolic sound may be short, a 'sound' rather than a murmur, and the second apical sound is then spoken of as pseudo-reduplicated.

Relation to mitral stenosis

That this mid-diastolic murmur may have some connexion with thickening of the mitral valve, such as may in time produce mitral stenosis, seems clear from two considerations. First, it is heard in exactly the same position as the presystolic bruit of stenosis and is as strictly localized as is that murmur. Secondly, it is not uncommon to

observe in an adolescent a short presystolic bruit becoming superseded by a mid-diastolic murmur as the heart quiets down under the influence of rest. On the other hand, it seems equally clear that by no means all mid-diastolic murmurs mean the ultimate development of mitral stenosis: in many instances they disappear in the course of time. Perhaps at the most it may be said that, when a mid-diastolic murmur is well marked and clearly and continuously audible over many weeks or months, the later development of mitral stenosis must be suspected, especially when the murmur is accompanied by accentuation of the first apical sound.

As regards the causation of this mid-diastolic murmur, D. B. Lees taught that it was due to such thickening of the mitral segments as impaired their mobility without producing actual stenosis. C. F. Coombs thought that disappearing bruits of this sort might be due to a relative stenosis, the mitral ring being less dilated than the rest of the left ventricle. The same murmur has also been attributed to partial heart-block and to adherent pericardium. The mid-diastolic type of the so-called Austin Flint murmur is probably the same phenomenon.

Aortic valvulitis is common in children and produces in them regurgitation but not stenosis. According to Horder aortic valvulitis is particularly common in the endocarditis occurring during scarlet fever.

Aortic endocarditis of rheumatic origin shows but few differences in children from the similar lesion in adults. The pallor which is apt to be present in adults is not seen in children, who present the same complexion in all cases of carditis. The diastolic murmur is soft but is usually easily audible; it is generally best heard in the third left space next the sternum rather than at the aortic area. It tends to be conducted down the left side of the sternum and may sometimes be heard towards the outer side of the apex beat.

Aortic stenosis due to rheumatism is rare in adults and practically unknown in children. In them signs pointing to aortic stenosis should lead to a suspicion of a congenital heart lesion or of malignant endocarditis.

Tricuspid endocarditis is present in a fair proportion, perhaps a quarter, of cases of fatal rheumatic carditis in children. How often it occurs in surviving cases cannot be computed, as it seldom gives rise during childhood to signs or symptoms by which its presence can be detected. The pulmonary valves appear to be immune to juvenile rheumatic infection.

(3)—Pericarditis

Pericarditis completes the triad in rheumatic carditis and is correctly regarded as the most dangerous form of cardiac rheumatism. Its immediate dangers are due to the facts that it denotes a severe rheumatic infection, and that myocarditis and endocarditis are not only invariably present but tend to be of great severity. The myocarditis is the cause of death in acute rheumatic pericarditis in either of its stages of friction

Ultimate dangers

or of effusion. The ultimate dangers of pericarditis are concerned with the severely damaged condition in which the heart may be left with the consequent increased liability to recrudescences of carditis and the possible formation of dangerous adhesions—chronic adhesive mediastinitis (see p. 246 and MEDIASTINUM DISEASES).

Acute pericarditis therefore denotes a severe rheumatic infection, and thus it is seen with high fever (103° F. or more), multiple arthritis, severe chorea, and subcutaneous nodes. As mentioned above, this, the most severe form of rheumatic carditis, is becoming less and less frequent.

Onset

Acute pericarditis may show three modes of onset:

(i) By far the commonest is in the course of a prostrating attack of rheumatic infection, marked by high fever and perhaps subcutaneous nodes, the pericarditis being suspected on account of the height of the fever and confirmed by the discovery of pericardial friction.

(ii) Acute pericarditis may also develop much more quietly. Although this is a much less common mode of onset, it is not very rare to discover pericardial friction in a rheumatic child not too ill to be brought to hospital as an ordinary out-patient. In such cases the myocarditis is not yet severe; hence the lack of urgent symptoms. Such a condition may be conveniently called one of primary rheumatic pericarditis, and, although such cases react well to treatment by salicylate, it is probable that before recovery severe damage to the myocardium will develop.

(iii) Still more insidiously acute pericarditis may develop in a heart already crippled by previous attacks of pericarditis. In such instances pericardial friction may be slight, evanescent, or even absent.

Symptoms and signs

The symptoms of acute pericarditis are for the most part those of acute and severe myocarditis, and have already been described under severe acute carditis (see p. 240). The degree of illness produced is great, because the dilatation of the heart, consequent upon the myocardial damage, is not only severe but of rapid onset. The intense rheumatic toxæmia, the high fever, and the restlessness of the child further increase the gravity of the illness.

In addition to the symptoms of the intense myocarditis there are two symptoms peculiar to pericarditis, neither of which, however, is present in most cases. The first of these is precordial pain corresponding to the pericardial friction; and the second is puffiness of the eyelids, usually more marked in the upper lids.

Pericardial friction

Pericardial friction is the distinctive sign of pericarditis, and the scratching or even rougher sound of the friction is often characteristic of the rheumatic type of pericardial inflammation. This sound is usually heard earliest at the base of the heart towards the pulmonary area or down the left side of the sternum, but it may be wide-spread over the precordial area. It may be systolic, or both systolic and diastolic; occasionally an auricular presystolic element can be detected in it. Sometimes the friction will run over the heart sounds, being confined neither to systole nor to diastole. The sound of pericardial friction is

more scratchy than that of a valvular murmur and, moreover, it does not follow the well known murmur paths. *Diagnosis from murmur*

It is important also to notice if the friction extends round the edges of the heart (external pericarditis) and between the heart and the lungs. In this event the friction will be influenced by the respiratory as well as by the cardiac rhythm. Such external pericarditis adds much to the danger of the future development of adhesive mediastinitis. *External pericarditis*

In association with acute pericarditis there are usually abnormal signs at the base of the left lung, in the lower axilla, and posteriorly. There may be a direct extension of the inflammation from the pericardium to the pleura, giving rise to friction or effusion, i.e. rheumatic pleurisy. Commoner are signs of congestion, broncho-pneumonic consolidation and collapse (partial or complete) in the lower lobe of the left lung. These pulmonary conditions appear to depend upon compression of the lung by the greatly enlarged heart rather than directly upon the presence of acute pericarditis; but in a peculiar form of consolidation running an afebrile course, which he termed the 'rheumatic lung', A. E. Naish demonstrated histological changes of the rheumatic type. This suggests that perhaps rheumatic infection plays a part in the production of these various pulmonary conditions. Similar changes at the base of the right lung are rare. *Associated signs*

Acute pericarditis may subside in the dry stage: then the friction will disappear as the temperature falls and the child improves. Often, however, it passes on to a stage of pericardial effusion: then the friction will disappear while the raised temperature persists and the child remains unimproved. *Pericardial effusion*

Effusion in rheumatic pericarditis in a child is nowadays of little practical importance. The effusion is small in amount, it is not in itself a danger or a cause of death, and it is neither necessary nor safe to attempt its aspiration. The dangers of pericarditis, even in its stage of effusion, still come from the immense dilatation of the heart from the severe associated myocarditis. Consequently the recognition of the presence of effusion is of no great moment, and this is fortunate, because the signs of its presence are equivocal. The condition is one in which there is a small effusion overlying a greatly dilated heart, and the signs of its presence are not distinctive as in tuberculous pericardial effusion, in which there is a large effusion surrounding a heart of normal size. Various physical signs of pericardial effusion are described, but in rheumatic cases, for the reasons given, none is of great value. The most suggestive are the great enlargement of the cardiac dullness, especially upwards, the distant character of the heart sounds, and the resistant dullness over the praecordia. Radiological examination should not be undertaken in such gravely ill children. *Significance*

The diagnosis of rheumatic pericardial effusion is best made not by these signs but by consideration of the progress of the case. When friction disappears while the temperature is sustained and the child unimproved, especially if there is a further increase in the area of cardiac *Signs of effusion*

The diagnosis of rheumatic pericardial effusion is best made not by these signs but by consideration of the progress of the case. When friction disappears while the temperature is sustained and the child unimproved, especially if there is a further increase in the area of cardiac *Diagnosis of effusion*

dullness, effusion should be suspected. The diagnosis will be confirmed if, a week or ten days later, the friction reappears accompanied by a falling temperature and improvement in the child's general condition.

Adherent pericardium

The term adherent pericardium, used clinically, means that the pericardium is not only adherent to the heart-muscle but also to the structures outside the pericardium, i.e. lungs, chest wall, and diaphragm, the state which is accurately described by the cumbersome term chronic adhesive mediastinitis. The attachment of the heart through the diseased pericardium to the external structures loads the heart with much additional work; and if the adhesions are sufficiently complete, little room is left for the growth of the heart as the child develops. As the result of its difficulties the heart becomes as greatly enlarged as is needful or possible, and the child tends to remain stunted in growth and retarded in physical development (cardiac infantilism, see Vol. IV, p. 304). Even in this condition, in which the mechanical handicaps of the heart are at a maximum, the onset of cardiac failure always denotes fresh cardiac infection. These symptoms have been given under acute carditis in the cardiac cripple (see p. 241).

Signs

The heart is much enlarged. Precordial bulging is common, and the scars of leech bites may be present over the heart. There are also the signs of valvular disease, usually multiple and severe. Many signs of pericardial adhesions are described, of which the least unreliable are the following: (i) fixation of the apex beat, with the result that it does not shift to the right when the child rolls off his back on to his right side; a large heavy heart, if free to move, shows shifting of the apex beat in these circumstances; (ii) systolic retraction of the interspaces near the apex beat, which increases rather than disappears when the child is rolled on to his right side; any very large heart may cause a similar retraction of the interspaces with each systole in the supine position, but if it is free to move it will fall away from the chest wall in the right lateral position and the retraction will cease; (iii) cardiac pulsation produced by adhesions between the heart and the diaphragm and visible in the region of the lower ribs posteriorly on the left side (J. Broadbent's sign); and (iv) enlargement of the heart greater than can be accounted for by the valvular lesions present.

Fixation of apex beat

Systolic retraction of interspaces

Broadbent's sign

Cardiac enlargement

(4)—Arrhythmia

Arrhythmia plays but a small part in rheumatic heart disease in children. Bradycardia of mild degree is fairly common during convalescence from a rheumatic attack and is a good rather than a bad sign. A simple tachycardia may be a prelude to the onset of carditis (see p. 239). The juvenile or respiratory type of arrhythmia disappears as the heart becomes actively infected, and its restoration suggests that the carditis is no longer active. Premature contractions may be found in rheumatic children but are not of any particular significance in active carditis. Auricular flutter and fibrillation are both very uncommon during childhood, even in advanced valvular disease. Heart-block in

Bradycardia

Tachycardia

Premature contractions

Heart-block

its slightest forms can be proved by the electrocardiogram to be present in a fair proportion of cases of active rheumatic carditis, even in early stages. This is of theoretical interest as showing the organic basis of rheumatic damage to the heart. Complete heart-block may appear in extremely rare instances as the first sign of rheumatic carditis or even of rheumatic infection (see p. 239).

(5)—Stage of Recovery

Special attention must be paid to the stage of recovery in rheumatic carditis in children, because it raises important and difficult problems. The chief question which arises is: on what evidence may the practitioner be satisfied that all active damage in the heart has come to an end?

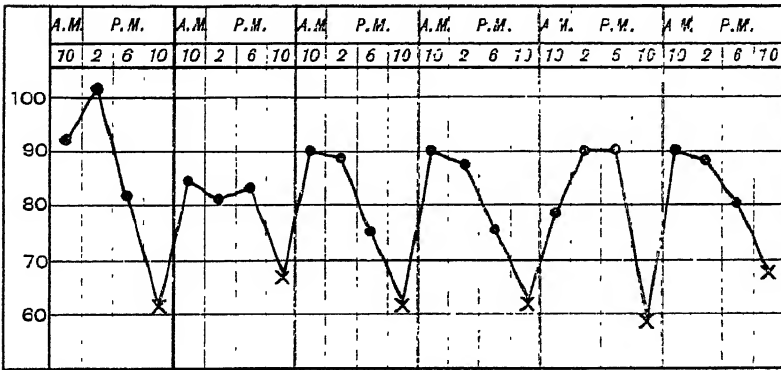


FIG. 36.—Pulse chart of a lively five-year-old boy in bed with suspected active rheumatic carditis, showing significance of the sleeping pulse-rate (x)

An attempt to answer this question may be made by the consideration of the following points:

(i) A child with active carditis neither looks nor feels really well; therefore constitutional improvement—a gain of flesh, colour, spirits, and vitality—is important evidence of the quiescence of active infection. *Signs of quiescence*

(ii) A return of the pulse-rate to normal figures affords proof in the same direction; but here the most reliable guide is the pulse-rate during sleep. This observation is most important, and in any doubtful case it should never be omitted (see Fig. 36). *Pulse-rate*

(iii) A return of the temperature to the normal points in the same direction, but here caution is advisable. A chart showing a regular evening rise of temperature above normal may be taken to indicate active infection; but, even if the night temperature readings remain at or below normal, a persistent and regular saw-like temperature graph should be viewed as indicative of low-grade activity. *Temperature*

(iv) The reappearance of sinus arrhythmia suggests cessation of active carditis; its non-appearance is quite inconclusive. *Sinus arrhythmia*

(v) Normal readings of the sedimentation-rate (see Vol. II, p. 491)

Sedimentation-rate

afford satisfactory evidence of freedom from active carditis (Perry). Single readings are unreliable.

Significance of signs

Studies of the leucocytic reactions of the blood do not afford a sufficiently delicate test to be of clinical value in this matter.

The diagnostic points enumerated above work only one way; that is to say, if they are all satisfactory, it may be concluded that active carditis has ceased; whereas, if they are unsatisfactory, the continued presence of infection or toxæmia must be inferred, but it does not necessarily follow that it originates in the heart.

Tonsillar infection

This leads to a subsidiary problem which may arise in connexion with the recovery stage in rheumatic carditis; a child may continue to look ill, with raised pulse and temperature readings, owing to active sepsis in the tonsils and not to active carditis. This dilemma is uncommon, which is fortunate, because much experience and patience are needed to reach a conclusion in such circumstances. It is well to play for time; as a general rule, when a child with obvious tonsillar sepsis has remained after a rheumatic attack stationary and unimproved for not less than six weeks, in the absence of active rheumatic symptoms, tonsillectomy should be undertaken.

5.—COURSE AND PROGNOSIS

Length of attack

The course of rheumatic carditis in children is extremely variable in length and severity. Roughly, the length of the attack depends chiefly on the severity of the infection and the degree of previous cardiac damage. The most severe infection, the really fulminating carditis which can kill a child in four days, is becoming very rare; but even this year (1937) I have seen a five-year-old child die within six weeks of his first known symptom of rheumatism. Severe infections, especially those with pericarditis and nodes, will be six to twelve weeks before they subside satisfactorily; but the longest cases of all, necessitating six to twelve months in hospital, occur in the cardiac cripples, especially those with pericardial adhesions. On the other hand, there are scores of rheumatic children with mild valvular disease, admitted to hospital for a recrudescence attack, whose temperatures are normal within a week and who are well in a month.

Effect of tonsillectomy

Once all active carditis is at an end the heart rapidly improves. Convalescence is quicker and smoother in tonsillectomized rheumatic children than in those with septic tonsils.

Recrudescence

One of the chief characteristics of juvenile rheumatism is its tendency towards relapses and recrudescences; this is especially true of cardiac rheumatism. This fact vitiates all attempts at accurate prognosis in rheumatic heart disease in children, because it is very difficult to forecast the likelihood of future attacks. All that can be said is that this danger is increased by such factors as perpetual subnormal health, bad environment, exposure to epidemic throat infections, septic tonsils, and an

already severely damaged heart. The rheumatic child of the hospital class, under the age of about fifteen years, living in its own home, seems hardly able to acquire a reliable immunity to this disease.

Apart from the danger of recrudescences there is much that warrants a favourable prognosis in all cases except the real cardiac cripple with a greatly enlarged and severely damaged heart. First, it is known that for many years to come the real danger to the heart consists not of mechanical overstrain but of fresh cardiac infection. Secondly, rheumatic carditis, although it often relapses, is not essentially a progressive disease. Thirdly, the comparative freedom from damage of the coronary arteries ensures both good compensation and freedom from sudden cardiac catastrophes.

Pure mitral regurgitation, especially when the left ventricle is only slightly enlarged, may pass off within five years in perhaps as many as a quarter of the cases. When the apex beat of the heart is more than an inch outside the mid-clavicular line, such a recovery is unlikely; and, when there is an added mid-diastolic murmur, the possibility of later development of mitral stenosis must be borne in mind (see p. 242). *Mitral regurgitation*

Aortic regurgitation, once established, remains as a permanent lesion in all cases. *Aortic regurgitation*

Deaths from rheumatic carditis are uncommon during childhood. Very severe first attacks account for some deaths; if they leave the heart severely damaged, the patient may die during childhood either from a recrudescence attack which unexpectedly gets out of control or more commonly from a series of renewed attacks which lead to increasingly long stays in hospital and gradually shortening periods of health. Even so, the real cardiac cripple, whose early death can be long foretold, more commonly dies in his teens than under the age of twelve years. The outlook is much worse in those cases of great cardiac enlargement due to extensive myocardial damage and pericardial adhesions than in the more purely valvular cases, even although aortic regurgitation is added to the mitral disease. *Fatal cases*

The supervention of malignant endocarditis in rheumatic valvulitis is very rare during childhood. The prognosis in rheumatic heart disease in adult life is discussed in other articles under the title HEART DISEASES.

6.—DIAGNOSIS

Rheumatic heart disease may be overlooked in a child. In the first place, the practitioner may fail to recognize that he is dealing with a case of infection by rheumatism. The prodromal symptoms of juvenile rheumatism have already been given (see p. 239), and the rather indefinite picture described may easily be mistaken for some other infection, especially early tuberculosis, unless careful inquiry is made into the occurrence of muscular pains in the legs, arms, and neck.

Again, heart disease may be overlooked owing to faulty methods of examination. Before any heart can be pronounced normal at any age, *Examination of heart*

but especially in childhood, the chest must be examined in both the upright and the supine positions. If there is any suspicion that the heart is enlarged, i.e. outside the mid-clavicular line in a child, the heart should also be examined with the child lying on his left side.

Non-rheumatic heart murmurs

Lastly, misinterpretation may lead to an incorrect diagnosis of rheumatic heart disease, particularly in connexion with mitral disease. Haemic and exocardial bruits should be distinguished from that of mitral incompetence by the absence of enlargement of the left ventricle and by a study of the areas of maximum intensity and conduction paths of the murmur. Most difficulty arises in connexion with a harmless congenital patent interventricular septum (see p. 227). This is distinguished from mitral regurgitation on the same lines. The heart is not enlarged, and the systolic murmur, although audible at the apex, is not conducted into the axilla and shows its maximum intensity not at the apex but close to the left border of the sternum in the fourth left space.

The distinctive features of mitral and aortic lesions are given on pages 241 and 243, and those of pericardial friction and effusion on page 244. The differentiation of active and quiescent cardiac rheumatism in children is discussed on page 247.

7.—TREATMENT

Prophylaxis

The prevention of rheumatic heart disease in children is naturally closely associated with the subjects of the prevention of juvenile rheumatism and its early diagnosis.

Prodromal stage

The prodromal stage of juvenile rheumatism and carditis, sometimes wrongly called the pre-rheumatic stage, often lasts for many weeks before there is an acute flare-up of the infection. During this time is the best chance to prevent serious heart disease, and the measures to be adopted are the same as those described in the after-care of children known to be rheumatic (see p. 253).

Remedial treatment

General

The remedial treatment of heart disease and its symptoms in children is the treatment of an active infective disease. Rest, in order to spare the infected heart, is of prime importance, and every rheumatic child with a raised temperature should be put to bed and given salicylate. The bed may be made up with sheets in the ordinary way, the child adopting whatever position is most comfortable. At least one pillow may always be allowed, but when there is serious dyspnoea the child should be well propped up with a fixed 'donkey' under the legs. In these urgent cases the child should not be allowed to do anything for himself, the danger of a sudden fatal collapse from exertion being very real. Diet should be on ordinary invalid lines in quantities suitable for the digestion. Sugars and predigested starch are of value. There is no virtue in underfeeding during acute phases, and in convalescence plenty of food, including meat, should be given. Constipation must be obviated,

especially during the administration of salicylate: mild aperients, assisted by glycerin suppositories or enemas, should be prescribed.

Local measures to the precordial area appear of value only in acute pericarditis. Three or four leeches applied over the heart probably reduce inflammation in this condition; more certainly they relieve pain and ease the right heart by the abstraction of blood. The leeches should be kept hidden from the child's sight: a very ill child must not be frightened. Less efficient are such counter-irritants as kaolin poultice (antiphlogistine) or light poultices applied to the chest wall, which has been painted with weak solution of iodine. If signs of active infection are present in the nose or throat, local treatment by means of sprays and oils should be given. *Local*

Salicylate cannot control the carditis of rheumatism as successfully as it can the arthritis, but its action is often unduly decried because the reason of its limitation is not understood. The anti-rheumatic action of the drug can only influence directly the inflammatory interstitial changes in the heart (see p. 238), and on the important parenchymatous changes it can have at most only an indirect effect. Thus its action is not unsatisfactory when the damage in the heart is chiefly due to active inflammation, as in many cases of early acute carditis and notably in the primary type of acute pericarditis (see p. 244); but it is handicapped in its action when advanced parenchymatous changes, acute or chronic, are the chief factor in the production of the symptoms, as in pericarditis with severe myocarditis or the subacute carditis of the cardiac cripple. Its action is further handicapped in severe carditis, acute or subacute, by the fact that this is the type of case in which it often cannot be tolerated by the child. When severe cardiac dilatation is present, vomiting may easily ensue, and in such instances salicylates may precipitate troublesome or even harmful vomiting. *Salicylate*

These difficulties make it all the more necessary to be skilled in the administration of salicylates. The development of cardiac symptoms in a child with rheumatic heart disease invariably denotes the presence of acute and active rheumatic carditis, and salicylate therapy should be attempted as a routine treatment. Daily doses of sodium salicylate from 60 to 100 grains should be given; to get the best results attention should be paid to the three following points: *Method of administration*

(i) An equal dose of sodium bicarbonate should be prescribed to allay gastric irritation and to avoid acidosis.

(ii) Sodium salicylate should always be given in small and frequent doses, because it is rapidly absorbed and rapidly excreted. It should therefore be given during the night as well as the day; experience shows that a dose of familiar medicine during the sleeping hours disturbs the child hardly at all. It is rarely wise to give a child more than 10 grains of sodium salicylate in each dose for fear of inducing vomiting. The required dose should be given at least four-hourly day and night; if more than 60 grains are needed in the twenty-four hours, the appropriate amount should be divided into ten doses and given two-hourly by day and four-hourly by night.

(iii) Constipation must be prevented, especially if the dose of salicylate is being increased.

When salicylate induces vomiting it should be stopped for twelve to twenty-four hours and then resumed in half-doses.

Acetyl-salicylic acid

Acetylsalicylic acid (aspirin) is more slowly absorbed and excreted than sodium salicylate, but it cannot be prescribed with alkalis and is therefore more irritating to the stomach. Its additional sedative action, so valuable in chorea, does not render it preferable to the sodium salt in the treatment of carditis.

Sedatives

Insomnia and restlessness must be treated. Acetylsalicylic acid and bromide are usually too mild to be of value. Carbromal is more potent and has no drawbacks. Children take it well, either as a tablet or a powder suspended in milk, in repeated doses of 5 to 10 grains. It is of particular value in carditis associated with chorea. When from the severity of the carditis there is great restlessness with delirium and lack of sleep, opium, usually in the form of morphine, should be used. In severe pericarditis a hypodermic injection of morphine may be invaluable. When the restlessness and pain are important factors adding to the heart's distress, morphine may act like a charm and save life. One-twelfth of a grain of morphine sulphate may be administered hypodermically to a child of twelve.

Digitalis

Digitalis plays a very minor part in the treatment of rheumatic heart disease in children. Fibrillation is rare, and the fact that active infection is present in the heart renders digitalis of little use during the acute stages; but in convalescence it may be of value, and perhaps it might be used rather earlier and more often at this stage than is customary.

Other measures

In other ways the treatment of carditis in children is on the same lines as the treatment of rheumatic heart disease in adults. Perhaps brandy is of additional value in the young: in moderate doses it appears to relax the peripheral circulation and to promote comfort and restfulness. It is also a food. Coramine works satisfactorily in children; strychnine is often worse than useless.

Convalescence

When the cardiac infection is truly quiescent, convalescence proceeds quickly. With constitutional improvement, a normal temperature, and a normal sleeping pulse-rate, extra pillows may be allowed which give the child the added exercise he requires. Elaborate graduated exercises are unnecessary in children who so quickly show fatigue by their looks. Massage to the limbs and back should be given if the child has been long in bed. Iron may be required and tonics to promote appetite. A dose of salicylate should be given night and morning throughout convalescence; acetylsalicylic acid with its slower action is here preferable. Gradually the child sits up in bed for his meals, gets up on a couch, and then begins to walk. Breakfast in bed, afternoon rests, and early bed-times should be continued until the child's health is fully restored. Prolonged rest in bed on account of a murmur, when the child is looking well and is full of vitality, should be deprecated.

Convalescent homes, other than heart homes, will rarely accept heart

cases, nor do children with recent carditis do particularly well in them. It is better to return the child to its home from hospital or to send it to relatives in the country.

Special care and supervision are necessary to prevent heart disease *After-care* appearing or increasing in rheumatic children. To this end many rheumatism supervisory centres have been established in the bigger towns, mainly in connexion with children's hospitals. The children are regularly inspected; their homes are visited and their parents instructed; treatment for every phase of rheumatism is available for the children. In this work the following points require attention:

(i) Examinations of the heart should be made at frequent intervals, *Cardiac examinations* because parents cannot always tell how their children are faring in this disease. In private practice it would be well if rheumatic children were kept under observation for at least two winters after an acute attack.

(ii) The home environment must be improved as far as possible. Damp and dilapidations should be reported to the Local Authority. Every effort should be made to provide the child with good clothing, water-tight boots, and warm dry rooms, especially bedrooms. The changing of wet clothes is important. The parents should be instructed in the *Personal environment* special care required in rheumatic cases (see p. 254). *Instruction of parents*

(iii) The ordinary elementary school is a source of danger to the *School* rheumatic child; use should be made of the invaluable schools for the physically defective. All children with well marked heart disease should attend there, and those with slighter heart lesions combined with poor constitutional health are better there, at all events for some time. Swimming, as a rule, should be forbidden, but ordinary drill and games *Games* are well within the scope of many of the slighter forms of heart cases.

(iv) Rheumatic symptoms must be promptly reported and treated. All catarrhal colds and sore-throats, epidemics of haemolytic streptococcal throat infections, influenza, scarlatina, diphtheria, and measles are all special dangers to rheumatic children. Convalescence should be strictly treated, and salicylate in full doses should be given for at least a fortnight to cover the dangerous period for a possible recrudescence of rheumatism. *Intercurrent disease*

(v) Long before the term focal sepsis was invented the close association *Tonsillectomy* between tonsillar disease and juvenile rheumatism was fully recognized, and it cannot be theoretically correct to leave septic tonsils unremoved in this disease. Some profess to be disappointed in the results of this operation, stating that it does not necessarily prevent future attacks of rheumatism; but this, it must be emphasized, is not the point: the point of importance is whether or not the operation tends to diminish the incidence of carditis. In this vital matter the evidence is in favour of the operation, especially if done in the early stages of rheumatic infection. The following points may be put forward in support of this view:

(a) In the large group of children with sore-throats and muscular pains, the commonest prodromal symptoms in juvenile rheumatism,

early tonsillectomy appears to diminish the incidence of serious rheumatism and carditis.

(b) Acute rheumatic attacks in tonsillectomized children show a diminished incidence of carditis. In them there is a very high proportion of cases of chorea without heart disease; and, as C. F. Coombs stated, it takes a smaller dose of rheumatism to produce chorea than the other manifestations of the infection.

(c) Tonsillectomy tends to abolish the spontaneous attacks of sore-throat to which rheumatic children are so prone and which are so often followed by fresh infection of the heart.

(d) Convalescence from an attack proceeds more quickly and smoothly in tonsillectomized patients than in those with septic tonsils.

On the other hand, tonsillectomy does not protect against haemolytic streptococcal throat infections and the rheumatism consequent upon them. Epidemic infections of this type form a serious danger to rheumatic children, especially in hospitals and schools. There is some justification for the hope that drugs of the prontosil type will be an effective aid in this difficulty. Again, the protective influence of tonsillectomy is much diminished in late cases with advanced heart disease, until in the true cardiac cripple it can hardly be expected to exert an influence for good.

*Special
precautions*

Arrangements for the removal of tonsils in a child with established heart disease should be made with special precautions. The child should be in bed under observation and taking salicylate for at least three days before the operation and, if possible, for ten to fourteen days after. The danger of the operation is the possibility that a rheumatic attack will supervene, but this is almost abolished if the above precautions are taken. With this qualification the tonsils can be safely removed in the fourth week after an attack of rheumatism, and it is an advantage to have the operation performed before the convalescent child leaves the hospital.

*Instructions
to parents*

The following instructions are issued to parents by the Paddington Green Children's Hospital:

ON THE CARE OF RHEUMATIC CHILDREN

1. Rheumatism is caused by infection by a germ and is a common disease of children, in whom it often attacks the heart. This is the great danger of the disease. Rheumatism is the commonest cause of heart disease in children.

2. Rheumatic attacks of all sorts often start with a sore-throat. A sore-throat in a rheumatic child is always a dangerous symptom.

3. Common symptoms of rheumatism in children are:

Sore-throat
Pains in muscles
Painful joints

Paleness
Shortness of breath
Fidgetiness or nervousness

4. Chorea, or St. Vitus's dance, is rheumatism attacking the brain.

Its chief danger is the tendency for the heart to be injured at the same time. Unusual nervousness, disturbed sleep, fidgety movements, or a tendency to drop things may be warnings of St. Vitus's dance.

5. Rheumatic heart disease is often painless and may only be discoverable by a doctor's examination.

6. If the heart has been injured by rheumatism, its recovery is very slow, and permanent harm may be done by letting the child resume an ordinary life before recovery is satisfactory.

7. An occupation in life for a child with heart disease requires very careful choice.

8. Rest is very necessary for rheumatic children. They should always be put to bed early, and they should be made to lie down during the day if they seem at all tired or if there is any aching of the limbs.

9. Damp is bad for rheumatism: basements are dangerous. Rheumatic children should sleep in the sunniest and driest room available. If they get wet, their clothes should be taken off and dried at once. Watertight boots are especially important.

10. Rheumatism tends to recur, especially in the winter months.

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III.—PERICARDIUM DISEASES

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1.—INTRODUCTION

637.] The clinical features of pericardial disease were first clearly described by Lower in 1669. Towards the end of the eighteenth century the work of de Senac separated diseases of the pericardium more clearly from other cardiopathies, and the varied and often dramatic manifestations of this disease provided a rich field for the highly skilled clinicians

of the middle and latter part of the nineteenth century, Chevers, Griesinger, Wilks, Broadbent, and Pick. Since that time the developments of bacteriology, and more recently radiology, have enlarged and elaborated substantially our knowledge of these morbid states.

The varieties of disease that may attack the serous membranes investing the heart may be grouped broadly into infections (acute and chronic), aseptic inflammations, new growths which may be either primary or secondary, congenital abnormalities, and traumatic lesions. The first category is by far the commonest and embraces probably about 90 per cent of all cases of pericardial disease. The infective inflammations are principally due to rheumatism and pneumonia. It is generally held that inflammation of the pericardium arises very rarely, if ever, as a primary lesion. A degenerative condition characterized by progressive calcification rarely attacks the pericardium; how far this is a primary condition remains doubtful, but there can be little doubt it may be a sequel of chronic inflammation.

Types of lesion

2.—DEFINITIONS

Pericarditis is a term that is used to include all inflammatory lesions. Strictly it should be applied only to these, but it is often extended to include also the neoplastic group. 'Acute pericardial disease' is an expression that includes all acute inflammations, whether these are infective or not, and whether or not there is accompanying effusion; since pericardial disease due to new growth is apt, when effusion develops, to assume the character of an acute illness, this form of morbid process is often included in this acute group. 'Dry pericarditis' implies the usual tissue changes of inflammation in the pericardium but without the production of more than a sticky local exudate on the membranes. The form of dry pericarditis that accompanies cardiac infarction has been called 'pericarditis epistenocardica' (Blumer). When fluid collects in the pericardial sac, it is usually referred to as 'pericardial effusion' or 'pericarditis with effusion'. After recovery from acute pericardial disease there will probably be some adhesions between the visceral and parietal layers, and between the parietal layers and adjacent structures: 'chronic adhesive pericarditis' is then said to be present. This state is sometimes loosely referred to as 'pericardial adhesions'. 'Chronic constrictive pericarditis', 'concretio cordis', and 'Pick's disease' are terms sometimes used in referring to the more severe grades of chronic pericardial disease that interfere with the function of the great vessels and of the liver.

Pericarditis

Acute pericardial disease

Dry pericarditis

Pericarditis with effusion

Chronic adhesive pericarditis

Pick's disease

3.—AETIOLOGY

According to Cabot pericardial disease occurs in males three times as frequently as in females. No age is immune from such disease; congenital

Sex and age incidence

lesions may be present at birth, while at late age terminal forms of the disease may close the scene in some chronic illness previously unconnected with the cardiovascular system. But the second, third, and fourth decades of life are those in which disease of the pericardium is most likely to arise, since the severe infections which account for the great bulk of cases preponderate in the first half of life.

*Pericarditis
as sequel to
rheumatism
and
pneumonia*

Pericarditis is generally secondary to some underlying morbid condition. This is most frequently infective, and the two important infections in this connexion are rheumatism and pneumonia. In some countries or localities rheumatism is commoner than pneumonia; in others the reverse holds, and the principal cause of pericardial disease will also therefore vary in the same way. Infection of the tonsils or other less obvious focus of sepsis may indicate the source from which the disease has sprung. Tuberculosis is said to account for about one-tenth of all cases, producing a more chronic type of illness, and uraemia is the underlying disease in a similar proportion. Many patients with cardiac infarction develop an acute aseptic form of pericarditis, which may remain localized or spread over a large extent of the membrane.

*Septic foci
Tuberculosis
Uraemia
Cardiac
infarction*

*Enteric
Intrathoracic
suppurations*

Enteric fever is a rare cause. Sometimes disease in the neighbourhood of the heart, such as suppurative mediastinitis or empyema, will lead to inflammation of the sac, but this may also relate to more remote pathological conditions; thus pus may track into the thorax from collections within the abdomen associated with cholecystitis or appendicitis. A general infection, such as that due to osteomyelitis or erysipelas, may be the precursor of pericarditis. Pericardial effusions are a possibility whenever acute disease exists in the membrane, but it is rare for more than a small quantity of exudate to form when uraemia or coronary thrombosis is the primary cause.

*Generalized
infections*

*Congenital
lesions of
pericardium*

Congenital lesions of the pericardium are very rare. White (1931) classified them as follows: (i) absence or defect of the parietal pericardium so that the heart may lie in the left pleural cavity in company with the left lung; (ii) diverticulum of the pericardium; and (iii) lack of attachment of the parietal pericardium to the great vessels. If the connexion between the pericardium and a diverticulum becomes obstructed, the latter may swell and so embarrass the heart. Abbott in an analysis of 1,000 examples of congenital cardiac defects found pericardial anomalies in only 37 (3·7 per cent). According to Grant deficiency or absence of the pericardium does not necessarily cause cardiac enlargement, nor is it incompatible with active adult life.

*Traumatic
lesions*

Traumatic lesions of the pericardium result from violence, such as a blow causing fracture of the sternum. Punctured wounds sometimes occur with or without damage to the myocardium. Blood may then collect in the pericardial sac. If the puncture involves the visceral pleura as well, the pericardium may become filled with air (pneumopericardium).

4.—MORBID ANATOMY

The pathological processes of inflammation of the pericardium fall broadly into three stages. At the onset there is a dry congestion of the serous membrane; this latter puts out a scanty fibrinous exudate. The outpouring of fluid into the pericardial sac commonly follows. The patient may not survive this development, but if he does the fluid is gradually absorbed and a greater or less degree of permanent adherence of the membranes to one another and to neighbouring structures



FIG. 37.—Acute inflammation of pericardium (visceral and parietal layers) showing shaggy fibrino-purulent exudate

follows. This end-result sometimes occurs without the intermediate stage of effusion.

The morbid anatomy of dry pericarditis consists at first in an injection of the minute vessels of the membranes, which become reddened and lustreless. As the inflammation progresses, small quantities of fibrinous lymph form on the surface. The separation of such a surface at necropsy reveals a whitish-yellow, flaky, rough, and usually irregular deposit consisting of fibrin and endothelial and pus cells (see Fig. 37). *Dry pericarditis*

Continuation of the inflammatory process in the membranes provokes a freer flow of fibrinous exudate, which then begins to separate the visceral and parietal layers. Accumulations of such fluid may be so small as not to be detected clinically, or they may total as much as two pints or more. *Pericardial effusion*

It is clear from the foregoing aetiological and pathological considerations that fluid in the pericardium is generally an inflammatory exudate. The specific gravity is about 1,018. The fluid contains much albumin, *Constitution of pericardial fluid*

- clots on standing, and is amber in colour, clear or turbid. It may contain large numbers of polymorphonuclear leucocytes and then becomes thick—purulent pericarditis or pyo-pericardium being present. There is sometimes sufficient blood to tint the effusion, which is then referred to as haemorrhagic. Effusions due to primary or secondary neoplasms are often haemorrhagic, and cells of the growth may be found on centrifuging the fluid. A collection of pure blood in the pericardium (haemo-pericardium) is usually the sequel to injuries, or to rupture of an aneurysm of the aorta or the ventricular wall.
- Pus*
- Blood*
- Watery transudates*
- Some effusions are more watery, containing very little fibrin, and are more of the nature of transudates. These are apt to develop whenever the body becomes water-logged, as in extreme degrees of congestive heart failure and some forms of chronic renal disease.
- Tuberculous effusions*
- Tuberculous effusions accumulate slowly and consequently may reach a large size; they sometimes contain blood. A tuberculous origin may be suspected if there is a tendency to re-accumulation after tapping, and determined either by the discovery of the organism in the fluid or by the production of typical lesions on injection into a guinea-pig.
- Chronic pericarditis*
- The term chronic pericarditis embraces every variety and grade of chronic thickening of the membranes from the smallest patches without adhesions to complete obliteration of the pericardial sac with external adhesions to neighbouring structures. The most trivial form of chronic pericarditis is exemplified in the so-called 'milk-spot', which consists in a localized area of thickening unaccompanied by adhesions and obviously causing no impairment of the function of the heart. In other instances loose strands of fibrous tissue pass from the visceral to the parietal layer of the sac. Such adhesions, being solitary abnormalities and clearly devoid of any mechanical import, may also be regarded as insignificant.
- 'Milk-spots'*
- Chronic constrictive pericarditis*
- Chronic constrictive pericarditis (Pick's disease) implies the envelopment of the heart in a dense fibrous membrane derived from the pericardium. This consists essentially in the adherence of the two layers, sometimes as a sequel to acute pericardial disease, but frequently without any history of such an illness. The dense fibrotic membrane that represents the obliterated pericardial sac often becomes greatly thickened and hampers the heart both in systole and diastole. White (1931) and Sprague claim that rheumatism is rarely if ever a cause of this form of chronic pericarditis; most often the aetiology is unknown, but in some cases tuberculosis, pneumonia, or influenza has been held responsible. Small deposits of calcium are common in the thickened pericardium, and in rare instances the heart may become invested in an almost complete shell of calcified tissue.
- Chronic mediastino-pericarditis*
- External adhesion of the pericardial sac to neighbouring structures sometimes accompanies chronic constrictive pericarditis. This condition is usually known as chronic mediastino-pericarditis (see MEDIASTINUM DISEASES). The existence of important external adhesions is most unusual at necropsy, but in spite of this fact many an unexplained cardiac

enlargement has in the past been ascribed to hypothetical pericardial adhesions. Parkinson found that when cardiac hypertrophy accompanies chronic pericarditis the cardiac enlargement is no more than might be attributable to associated conditions such as valvular disease, hypertension, or chronic pulmonary disease.

5.—BACTERIOLOGY

The conditions responsible for the infective types of pericardial disease have been already mentioned in the section on aetiology (p. 258). In many instances the bacterial origin is obvious from the nature of the antecedent or associated infection; in others the lesions are undoubtedly non-bacterial. Between these extremes are a number of cases in which it is impossible to determine the nature of the infective agent, although in almost every one it is possible either clinically or at necropsy to decide whether the lesion is infective or not.

In pericarditis associated with pneumonia, pyaemia, osteomyelitis, gonorrhoea, or other gross infection there will be no doubt about the organism responsible. The tubercle bacillus may be difficult to find in cases of tuberculous origin, but careful examination of the fluid or inoculation into a guinea-pig may settle the diagnosis.

Pericarditis associated with infective disease

It is the rheumatic forms of heart disease and pericarditis that have evoked the greatest interest of bacteriologists in late years. Briefly, it is still disputed whether rheumatic heart disease is of streptococcal origin or not. Some believe that it is, others that an ultra-microscopic virus is responsible, still others that both the known streptococcus and the hypothetical virus are at work. The study of the pericardial exudate in rheumatic carditis has been a starting point in recent researches on this problem. Schlesinger, by rapid centrifuging, isolated an elementary body from pericardial fluid of an acute pericarditis a few hours after death. He found that suspensions of these bodies were agglutinated by serum taken from patients with active rheumatism and nodules. Coles reported the discovery of a virus in pericardial exudate in a similar case; he also found virus bodies in the synovial fluid of the knee-joint in several cases of rheumatoid arthritis. The subject is further discussed under the title RHEUMATIC INFECTION, ACUTE.

Rheumatic forms

6.—CLINICAL PICTURE

(1)—Acute Pericardial Disease

The presence of acute pericarditis with effusion is likely to be suspected only if the medical attendant is aware of the usual clinical preludes and of the manner in which the disease commonly develops. The most frequent form is that in which a young or adolescent patient suffering from acute rheumatism or rheumatic carditis becomes rapidly worse

Onset

with rising temperature and pulse-rate, and sometimes with severe pain in the sternal region. The clinical picture next in order of frequency is the child or adult, ill with pneumonia, whose temperature begins to swing after the fifth or sixth day, in association with increasing toxæmia and delirium, pericardial friction becoming audible over the precordial area. In other instances the patient has within the previous week or ten days suffered from tonsillitis or other infection; he has perhaps hurried his convalescence against medical advice and has been seized with increasing respiratory distress, signs of congestive failure appearing later. I have elsewhere (1935) described the clinical features of acute pericardial disease; they may be grouped under symptoms and signs as follows.

(a) *Symptoms*

*Respiratory
distress*

Some respiratory distress is present in most patients with dry pericarditis, and in all with pericardial effusions. Often the onset is painless, and with the development of effusion the respiratory distress increases rapidly to the stage of orthopnoea. This distress is brought about by compression of the heart and by limitation of free expansion of the lungs. When it is remembered that pericardial effusion may also embarrass respiration by the associated effusions in the pleurae, by pressure upon the left bronchus, and by obstruction of the venous return, the rapid evolution of the malady is readily understood. Acute pericardial disease constitutes one of the most dramatic forms of heart disease. The patient presents an aspect of acute distress, the ordinary orthopnoeic posture sometimes developing into a forward drooping of the head and thorax. In its extreme form even the genu-pectoral posture may be reached; this manifestation has been described by Blechmann as the '*signe des attitudes*'.

*'Signe des
attitudes'*

Respiratory distress in pericardial effusion may take another form, in which the respirations synchronize with the heart-beats.

A boy of sixteen, who had been attending Charing Cross Hospital as an out-patient on account of chronic rheumatic valvular disease, was admitted in acute respiratory distress. Pericardial friction was present, and for three days the respiration rate was 84 per minute, the same as the heart-rate. This patient showed a typical attitude, lying propped up on the right side with the body bent forwards and the head on a pillow close to the knees. Subsequent necropsy confirmed the diagnosis of acute pericardial inflammation with effusion.

Pain

When pain is the cardinal feature of the onset it occurs generally in the sternal or parasternal regions. The complaint of acute pain in the chest by a patient under forty years of age should raise the suspicion of acute pericarditis. Not uncommonly the pain is in some measure related to respiration and is aggravated by a full breath. Occasionally the pain may closely simulate a severe anginal attack. The relation of the pain to respiration and its occasional reference to the shoulder and upper quadrant of the abdomen suggest that involvement of the pleura and diaphragm is concerned in its production.

In general, when evidences of circulatory failure are present, the temperature is subnormal; but, since acute inflammation is responsible for most pericardial effusions, congestive failure is in these cases accompanied by fever. Acute pericardial disease causes one of the few febrile forms of heart failure. The blood in the inflammatory form shows a corresponding polymorphonuclear leucocytosis.

*Fever**Blood picture*

(b) Signs

Dry pericarditis gives only one physical sign—a friction sound on auscultation; occasionally this friction is also palpable. Starting as a soft shuffling or grating sound, usually between the left border of the heart and the lower part of the sternum, it sometimes becomes leathery or creaking, accompanying systole or both systole and diastole, but not synchronizing with the onset of either phase. Pericardial friction has the peculiar quality of sounding very close to the ear on auscultation. Whereas other intrathoracic sounds seem to originate deeply within the thorax, the shuffling sound of pericarditis seems to arise at some point between the chest piece of the stethoscope and the ear.

Auscultation

Some misconceptions have grown up in regard to the meaning of this sign. Clearly it must always indicate disease of the pericardium; but pericardial disease may exist in its absence, often because the sign is evanescent, sometimes because the inflamed area is related to the posterior regions of the heart. It is important also to realize that a pericardial rub may co-exist with a large effusion. The view that the formation of effusion led to the abolition of friction gained currency chiefly from the old idea that the heart sank back of its own weight in the distended sac of pericardial fluid. Actually, as was pointed out by Conner, the heart must remain in fairly close relation to the anterior chest wall however large the effusion.

Significance of pericardial friction

Several hundred cubic centimetres of fluid may collect in the pericardium before conclusive physical signs develop. The earliest evidence of effusion is usually radiological; this consists in a filling out of the dependent portions of the pericardium in the region of the inferior vena cava and the apex. These appearances are best seen in the oblique views on screening. As the amount of fluid becomes greater, the area of cardiac dullness becomes obviously increased, most notably outwards to the left, and upward and outward over the third left intercostal space.

Radiography

At the same time successive examinations reveal diminishing force of the cardiac impulse and weakening of the heart sounds. If at a single examination unusual dullness at the base of the heart is accompanied by increased dullness to the right and left of the sternum, and by contrasting feebleness of sounds and impulse, the likelihood of pericardial effusion must receive serious attention.

With the gathering of fluid in the pericardium, the diastole of the heart, and therefore its filling, will become restricted. Increased frequency and weakening of the pulse follow, and when effusion is considerable an

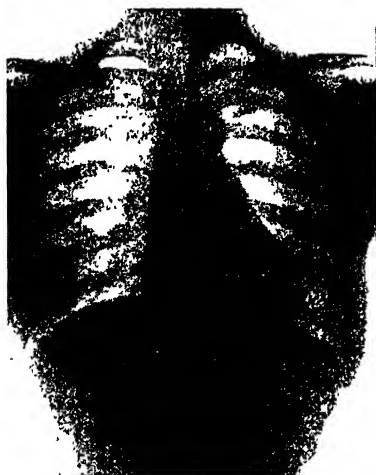
Pulse

inspiratory waning or even obliteration of the pulse is easily observed (pulsus paradoxus, or Griesinger-Kussmaul pulse).

*Signs of
distension*



(a)



(b)

FIG. 38.—Acute rheumatic pericarditis. (a) Showing pericardial and bilateral pleural effusions; (b) six weeks later, showing heart of normal size and contour, disappearance of effusions, and lower position of diaphragm

*Signs of
congestive
failure*

Since the heart occupies a position more or less fixed in the chest, and since fluid formed must be accommodated somewhere, it necessarily accumulates and bulges laterally and backwards on each side. The distension is greatest on the left side, giving rise to signs described by Ewart in 1896—a zone of dullness with tubular breath sounds extending from the angle of the left scapula downwards and inwards towards the lower dorsal vertebrae. Whether these signs are produced by mechanical pressure on the lung, by pressure on the left bronchus producing pulmonary collapse, or by any other mechanism is immaterial to the problem of diagnosis. In addition to these signs, there are very commonly reduction of movement, dullness on percussion, and weak breath sounds at both bases, due, as may be demonstrated by X-rays, to bilateral effusions into the pleural cavities.

While the local evidences of fluid in the pericardium are becoming more obvious, the patient is becoming more distressed. Signs of congestive failure appear—cyanosis, engorgement of cervical veins, oedema of dependent

parts, and enlargement of the liver. This hepatic enlargement is also due to local pressure by fluid upon the hepatic veins opening into the inferior vena cava.

*Position of
diaphragm*

It has been stated erroneously that the liver is displaced downwards by the accumulation of fluid in the pericardium; it is not difficult to demonstrate by serial X-rays taken during effusion and on recovery that the diaphragm actually occupies a higher position during the phase of

effusion than after its absorption (see Fig. 38). When a large quantity of fluid is present in the pericardium, the antero-posterior X-ray shows a characteristic shape of heart shadow—the right border sloping downwards and outwards to blend with a variable density at the base of the right lung, the left border being almost straight and directed at an angle of about 45° to fuse with a density at the lower part of the left pleural sac. The shadow of the vascular pedicle is frequently double the normal width at the level of the second intercostal space (see Fig. 38).

*Typical
heart
shadow*

The electrocardiogram is not of direct diagnostic importance in acute pericardial disease. It may show arrhythmia due to underlying myocardial disturbance. Often the curves are of low voltage, and deformities of the RT segments similar to those seen in cardiac infarction have been recorded.

*Electro-
cardiogram*

(2)—Tuberculous Pericardial Disease

Statistical evidence suggests that this lesion may occur at any age, that it is commonest in children, and that it is found at necropsy in 2 to 3 per cent of patients with tuberculous lesions. In fact this form of pericarditis is nearly always secondary to tuberculous involvement of the pleura, lung, or mediastinal glands, and as an isolated clinical entity is rare.

Incidence

Osler classified the disease into four clinical groups: (i) latent tuberculous pericarditis, in which the discovery is made accidentally at necropsy; (ii) symptoms of cardiac insufficiency following dilatation and hypertrophy of the heart consequent on chronic adhesive pericarditis; (iii) acute tuberculosis, either generalized or with manifestations principally referable to the nervous system; and (iv) the syndrome of acute pericarditis, with precordial pain, dyspnoea, oedema, and progressive deterioration of the general condition. The disease is generally rendered manifest by symptoms of thoracic distress, and examination may disclose a to-and-fro rub over the praecordia.

*Clinical
classification*

There are no signs of primary disease of the valves or myocardium, and if aspiration becomes necessary the effusion is as a rule found to be sterile. Centrifuging may reveal a few tubercle bacilli, but the true nature of the condition may only be proved by guinea-pig inoculation. In contrast to other forms of pericardial disease repeated tapping may be necessary. The fluid forms so slowly that a large amount may accumulate in the pericardium; and, as the myocardium is seldom involved by the tuberculosis, the functional efficiency of the heart is only gradually impaired.

*Examination
of effusion*

From Osler's classification it is clear that tuberculous disease of the pericardium may run an insidious course which is not incapacitating, the malady never being diagnosed. Probably such states constitute the basis of some cases of chronic pericardial disease in which the aetiology is obscure.

(3)—Chronic Adhesive Pericarditis

Symptoms and signs

The lesser degrees of pericardial adhesions do not cause any symptoms or signs. For example, it is obvious that local adherence of the serous membranes or the existence of loose strands connecting them cannot impair the function of the heart. There are two ways in which more extensive adhesions may hamper cardiac contractions; in the first a chronic pericarditis may unite the visceral and parietal layers and, by progressive overgrowth, cause increasing constriction which will not allow free relaxation and contraction of the chambers of the heart (chronic constrictive pericarditis); in the second the heart is exposed to abnormal stress with every contraction owing to dense adhesions binding it to the diaphragm, sternum, and other adjacent structures (chronic mediastino-pericarditis).

The clinical manifestations of chronic constrictive pericarditis depend upon the fact that the heart is mechanically crippled while the myocardium remains relatively unimpaired. In particular there is obstruction to the venous return by the hepatic veins, and this fact accounts for many of the striking symptoms and signs, which are summarized below (after White, 1931).

General symptoms

Abdominal enlargement, often accompanied by dyspnoea, is the most frequent symptom at the onset. Swelling of the feet, with or without abdominal swelling, is another mode of onset. Examination invariably discloses enlargement of the liver, which is not tender or pulsatile; ascites is usually present. The only other sign consistently present is engorgement of the jugular veins, which may or may not show pulsation. The venous pressure is usually trebled. Cyanosis accompanies the venous engorgement, and the clinical picture closely resembles that of congestive heart failure, except that there is a remarkable absence of orthopnoea unless pleural fluid is present. The examination of the heart occasionally reveals systolic murmurs, but diastolic murmurs or other evidences of valvular disease are absent.

Radiography

Radioscopy shows that the heart is as often normal in size as enlarged; a mitral configuration with prominence of the pulmonary artery and conus shadows may be seen; sometimes the heart is found to be abnormally fixed in position, with dense streaking, chiefly at the periphery, indicating calcification.

Electrocardiogram

As in pericarditis with effusion, the electrocardiogram generally shows a normal rhythm but sometimes auricular fibrillation; it often shows low voltage; in other cases the only abnormality may be inversion of the T-waves in leads I and II, suggesting interference with coronary irrigation. As might be expected in a heart which is gravely hampered, the blood-pressure and pulse-pressure are found to be low. Inspiratory weakening of the pulse (pulsus paradoxus) may be observed as in pericardial effusion.

Blood-pressure

Pulse

Diagnostic difficulties

In chronic mediastino-pericarditis the existence of even extensive adhesions is often very difficult to detect. The crux of the difficulty is

that, while external adhesions may invest a heart that is grossly enlarged, a large heart without chronic pericarditis may produce many of the physical signs commonly described as indicating the existence of chronic pericardial disease. Hence the frequency with which this condition first comes to light at necropsy.

Such physical signs as may be produced depend upon the anchoring of the heart to neighbouring structures. For example the fixation of the heart to the sternum may cause retraction of the xiphisternum during inspiration; from the same cause the left nipple may lag behind the right when the latter moves forward during inspiration. These signs, described by Wenckebach, are, when present, some of the best local indications of fixation of the heart to neighbouring structures.

Signs of fixation of heart

Adherence of the heart to the anterior margins of the lungs, particularly the left, will prevent the natural encroachment of the lung upon the anterior surface of the heart during inspiration: in consequence it is said that the area of cardiac dullness remains fixed during respiration instead of becoming smaller during the inspiratory phase.

Adherence to anterior margins of lungs

If adhesions bind the heart firmly to the left dome of the diaphragm, the latter may be dragged by each contraction of the ventricles so that a systolic retraction of the interspaces may be seen postero-laterally on the left side below the angle of the scapula. This sign (Broadbent's or Ewart's) may be present whenever the heart is grossly enlarged even in the absence of adhesions, but it is best seen in chronic pericarditis. The same criticism applies to the so-called 'wavy' cardiac impulse that is said to be a sign of this disease. Fixation of the apex beat in the left lateral posture as compared with the supine is not a reliable sign, because even a 'fixed' heart if it is heavy enough will produce an impulse further out when the body is in the lateral position.

To left dome of diaphragm

Broadbent's or Ewart's sign

It has been attempted of late to evolve an electrocardiographic sign of chronic adhesive pericarditis. This method depends upon the alteration of the electrical axis of the heart with change from the dorsal to either lateral position; it is argued that if the change of posture does not produce a change in the electrocardiogram the heart must be firmly anchored by adhesions. This technique may be of value, but its use remains to be assessed; the sign is probably not pathognomonic.

Electrocardiographic sign

7.—COURSE AND PROGNOSIS

Acute pericardial disease is so often a phase or complication of some underlying malady that the course and prognosis must depend very largely upon the clinical context. For example the evanescent pericardial rub heard in the course of otherwise uncomplicated cardiac infarction detracts little if at all from the chance of recovery; at the same time, an extending pericarditis of longer duration in the same malady undoubtedly means a large infarct and therefore a greater hazard. In the frequent instances of pericarditis complicating rheumatic

Importance of associated disease

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Signs of fixation of heart

Adherence to anterior margins of lungs

To left dome of diaphragm

Broadbent's or Ewart's sign

Electro-cardiographic sign

Importance of associated disease

fever or heart disease, the probability is that a greater or less quantity of fluid will collect, and that this will then gradually be absorbed without the necessity for tapping. Even large effusions of this origin which produce extreme cardiac embarrassment will probably not prove fatal if dealt with in time by aspiration, and provided the condition of the heart is satisfactory.

Pneumonia

The development of pericardial friction in pneumonia, or even of pleuro-pericardial friction, adds very much to the gravity of the illness. The extension of inflammation to a new serous surface must increase the toxæmia, and already in such cases there is usually a severe pleural and pulmonary lesion. If to these troubles is added the burden of pericardial effusion, the prospect of survival becomes poor, even if aspiration or, in the case of purulent effusions, open incision and drainage have been undertaken. On the other hand, not every pericarditis in pneumonia leads to effusion, nor is every effusion purulent, even if pus is present in one or other pleural cavity.

Tonsillitis

Sero-fibrinous exudates of doubtful aetiology, such as those which follow tonsillitis or some less definite infection, may or may not need evacuation; in any event the outlook here is good since there will be no underlying heart disease and the circulatory trouble will be largely mechanical.

General infections

In the grave infections, such as osteomyelitis or septicaemia from some other source, involvement of the pericardium renders the outlook more serious; this will be the more so if it is suspected or discovered that the effusion is purulent. Still, if suitable treatment is undertaken, the pericardial complication need not determine a fatal issue.

In some instances, acute pericardial disease is no more than an incident in the progress of a fatal illness; it may appear when secondary deposits from a primary mediastinal growth form in the pericardium. Sometimes pericarditis is a terminal incident in a prolonged illness, and does not even account for ultimate death; this may be the case in uraemia, when a dry pericarditis (rarely with effusion) is discovered in some cases during the last days or weeks of life.

Tuberculous disease

Tuberculous pericardial disease may be so latent that it remains unsuspected during life, the diagnosis being made at necropsy after death from some other cause. Sometimes it leads to progressive cardiac embarrassment. It has been mentioned already that lesions of this kind probably account for some of the cases of chronic constrictive pericarditis. When tuberculous pericardial disease is complicated by effusion the outlook is practically hopeless, but, by repeated aspiration and the use of diuretics and a salt-free diet, life may be maintained for about a year or two.

Chronic adhesive pericarditis

The prognosis in chronic mediastino-pericarditis is dominated by the gross valvular disease which is generally present. Survival for more than a few years is therefore unlikely, although rest, digitalis, and symptomatic remedies will help temporarily. On the other hand, in Pick's disease the prognosis turns upon the possibility of operative interference by

the Delorme method (see p. 275). If the patient is in the earlier decades of life and has no evidence of intrinsic heart disease, such as enlargement or auricular fibrillation, there is probably an even chance that the operation, if entrusted to expert hands, will be successful in bringing about a cure. The operation is highly specialized and the earlier cases of even an experienced and skilful surgeon stand a poorer chance than later ones. The course in unoperated Pick's disease is one of gradual physical deterioration with increasing congestion and distress due to abdominal distension, hepatic engorgement, and oedema. Probably unaided recovery never occurs, although patients less severely affected may continue a life of greater or less invalidism for years.

Congenital lesions of the pericardium may menace life in two ways. If there is partial or complete deficiency of the pericardium, the heart comes into close contact with the lung and therefore may become easily infected if pneumonia or empyema should occur. Further, the abnormal mobility of the heart in such congenital defects may allow compression or torsion of the great vessels and cause serious cardiac embarrassment or death. Otherwise, and in most cases, congenital lesions impair little if at all the expectation of life. *Congenital lesions*

8.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

Pyogenic bacteria, with the possible addition of ultra-microscopic viruses, are responsible for acute pericardial disease twice as often as all other causes put together; tuberculous infection is a rare cause. There are only four non-infective aetiological groups and they are all uncommon: pericarditis consequent upon cardiac infarction, terminal pericarditis in uraemia, inflammation due to a foreign body, and infiltration by new growth. *Aetiological diagnosis*

When pericarditis is a sequel to infarction of the heart, the onset of the illness and possibly a previous anginal history will suggest the pathological basis, and the electrocardiogram will often furnish crucial evidence. An uraemic basis of pericarditis will be suspected from the previous history of chronic renal disease, and from the condition of the patient, the urine, and the blood before the onset of the cardiac complication. Except in rare instances neither this form of pericarditis nor that related to coronary thrombosis gives rise to effusion. The relation of pericarditis to septicaemia or a foreign body will usually be self-evident. *Sequel to infarction*
Sequel to uraemia
Septicaemia
Foreign body

When a mediastinal neoplasm invades the pericardium, effusion may rapidly bring about circulatory embarrassment and progressive congestive failure unaccompanied by fever or any other evidence of an infective basis. The following case may serve as an example: *Mediastinal new growth*

A female, aged thirty-nine, attended the out-patient department at Charing Cross Hospital complaining of intense dyspnoea. Three days previously she had felt quite well. Examination showed orthopnoea and

cyanosis with engorgement of the neck veins and the liver, and oedema of the legs. Profound respiratory distress was present, and the small pulse at the wrist completely disappeared with each inspiration. The radiograph showed a characteristic shadow (see Fig. 39), and paracentesis of the pericardium brought large amounts of haemorrhagic fluid. The patient died after ten days' illness. The necropsy showed a lymphosarcoma in the superior mediastinum involving the pericardium.

Rheumatism

According to most statistics rheumatism is the principal infection underlying acute pericardial disease. In such cases there may be evidence from the history of rheumatic infection, or from the examination, of chronic rheumatic heart disease. Often acute inflammation of the joints will accompany the onset of respiratory distress with or without pain in the chest.

In other forms of infection, the inflammation of the pericardium may be an extension of neighbouring lesions in the pleura and lung; for example, serous or suppurative pericardial effusion may complicate pneumonia or empyema. In yet another infective group the relation of pericarditis to its origin may be more remote, as when the disease appears in a patient previously suffering from osteomyelitis.

Other causes



FIG. 39.—Pericardial effusion in mediastinal lymphosarcoma involving pericardium

Diagnosis in late stages

When the acute stage of pericarditis is past, and when, perhaps many years later, the patient is seen with manifestations pointing to chronic constrictive pericarditis or mediastino-pericarditis, the problem of aetiology is nearly always obscure and frequently insoluble. As already mentioned, Pick's disease or chronic constrictive pericarditis is rarely if ever rheumatic in origin, but may be due to tuberculous infection or to long-past acute infections such as pneumonia, influenza, or staphylococcal infections. When mitral disease with or without involvement of the aortic or tricuspid valves is discovered in association with mediastino-pericarditis, there can be no doubt that the whole condition is rheumatic in origin.

Differential diagnosis

Dry pericarditis

Dry pericarditis cannot be diagnosed unless a pericardial rub is heard. Such friction is not likely to be mistaken for any other sound discovered on auscultation. Occasionally harsh murmurs of exocardial origin

may cause confusion, but in such instances the clinical context and successive examinations will soon determine the matter. Inflammation of the adjacent pleura, as in left-sided pneumonia, will sometimes cause pleuro-pericardial friction. This is usually heard at the left border of the heart, and has the shuffling or grating quality typical of pericardial friction; but the fact that the sound is louder during inspiration and quieter while the breath is held, together with the evidence of primary inflammation in the lung, will in most cases clinch the diagnosis. When pleuro-pericardial friction is heard, generalized pericarditis is often imminent.

Pericardial effusion is likely to be mistaken for heart failure from other causes, owing to the rapid development of dyspnoea, orthopnoea, and congestion. The local signs in the heart, particularly the extensive dullness on percussion and weak heart-sounds, will generally indicate the cause of the rapid reduction in effort-tolerance; the pulsus paradoxus, the falling blood-pressure, and the increasing heart-rate will also suggest the mechanical embarrassment to which the heart is subjected. Difficulty may arise when effusion is not of great volume, or when both cardiac enlargement and effusion are present or suspected. Even exploration may lead to an erroneous conclusion, since pleural fluid usually co-exists, and may be mistakenly regarded as pericardial. If the pain of pericardial disease is referred to the abdomen, a false diagnosis of acute abdominal disease may be made.

*Pericardial
effusion*

Pick's disease, or chronic constrictive pericarditis, which is actually venous and hepatic congestion without failure of the heart-muscle, must be mainly distinguished from congestion due to chronic heart failure. In the latter condition the oedema appears first in the legs, and the overfilled neck veins pulsate; signs of mitral and possibly tricuspid disease together with gross enlargement of the heart are frequently present. Conversely, in Pick's disease there is preponderating swelling of the abdomen and little if any pulsation in the veins in the neck; signs of mitral disease are absent and the heart is either normal in size or at most moderately enlarged.

*Pick's disease
(chronic
constrictive
pericarditis)*

Differentiation from primary cirrhosis of the liver is not likely to cause difficulty, for this disease hardly ever occurs in the earlier decades of life and does not cause venous congestion in the neck. The history may help, the cirrhotic patient very often giving a history of alcoholism. Further, cirrhosis does not, like Pick's disease, affect the systemic circulation producing a paradoxical pulse with low pulse-pressure. It is true that chronic congestion evokes slight fibrosis in the liver but nothing approaching the coarse lobulation so often detected on clinical examination in multilobular cirrhosis.

*Differentiation from
primary
cirrhosis of
liver*

Although polyserositis or Concato's disease (see Vol. II, p. 157) frequently attacks the pleural and pericardial membranes, it is quite distinct from chronic constrictive pericarditis. Pick's disease usually is not associated with a thick 'icing' of perihepatitis (*Zuckergussleber*), although this condition may occasionally be found, particularly if a preceding polyserositis has invaded the peritoneum.

*From
polyserositis*

*Chronic
mediastino-
pericarditis*

The difficulties in the diagnosis of chronic mediastino-pericarditis have already been discussed (see p. 266). Many of the physical signs in this disease are also produced by grossly enlarged hearts that are free from external (or internal) adhesions. A previous history of acute pericardial disease will be a significant point. Radiological examination may disclose peaked projections from the cardiac shadow indicative of adhesion of the parietal pericardium to lung or diaphragm.

9.—TREATMENT

(1)—Preventive

As pericardial disease is not a specific malady but has many causes, there can be no specific prophylaxis. Prevention will therefore consist mainly in the avoidance of those infections—principally rheumatism—which most commonly produce it, and the careful and suitable treatment of such infections when they have developed. Prophylaxis, such as it is, is thus concerned with the avoidance of the infective rather than the non-infective inflammations of the pericardium. No method is known of avoiding the pericarditis of coronary thrombosis for example, or the involvement of the pericardium in new growths. On the other hand it is probable that the nature of the treatment may considerably modify the course of acute and other forms of pericarditis, the more acute the disease the more noticeable being the effect of treatment.

(2)—Treatment of Acute Pericardial Disease

(a) *General*

Acute pericardial disease is sometimes an incident in the course of another malady. Thus in cardiac infarction or uraemia the treatment is essentially that of the underlying disease. But very often acute pericarditis with effusion is the central feature of the illness and the adoption of suitable treatment may make all the difference between recovery and a fatal issue.

When pericarditis originates in rheumatic infection, the patient has probably been confined to bed with arthritis or carditis before the onset of pericardial involvement. If pericarditis is due to spread from neighbouring infection, the patient will have been previously under treatment for pneumonia or empyema. In other cases, as for example when the disease arises from occult infection, the patient is soon compelled to take to bed by the urgency of the symptoms. The patient is kept at complete rest in whatever position or degree of recumbency he finds most comfortable. If desired a firm support may be placed across the bed so that a forward-leaning posture may be easily adopted.

It is necessary to relieve pain and restlessness, and for this purpose the subcutaneous injection of morphine sulphate $\frac{1}{4}$ grain is most efficacious. Almost the only circumstance in which this treatment might be inadvisable is the coexistence of pneumonia at a stage later than the third or fourth day. In such cases, if the degree of pain and

*Relief of
pain*

distress demand it. morphine sulphate $\frac{1}{2}$ grain. with atropine sulphate $\frac{1}{16}$ grain. and strychnine sulphate $\frac{1}{16}$ grain. may be injected together. Local applications of heat and cold have been recommended for the relief of discomfort or pain, but the distress or the attitude may make such applications difficult, ineffective, or even impossible. The same considerations apply to the use of leeches.

Pericardial effusion is often a phase which is destined to pass, leaving the patient little the worse, if he can be tided over the circulatory embarrassment that invariably arises. For this reason the efficient use of oxygen may be a most important, even a deciding, factor in the outcome of the disease. The most comfortable method for the administration of oxygen to restless and delirious patients is by the use of a small nasal catheter in which several holes have been cut within an inch of the termination. The catheter is smeared with 1 per cent cocaine ointment and passed through the nostril until it projects beyond the uvula. The oxygen should be bubbled through at least six to eight inches of warm water at such a rate that the bubbles cannot be counted. This ensures sufficient moisture in the gas and prevents the irritant drying of the nasopharynx which so often ends in a refusal by the patient to continue with the treatment. From time to time the nasopharynx should be sprayed with liquid paraffin.

Like other forms of heart failure, that arising from pericardial effusion should be treated by digitalis. Tablets of standardized digitalis powder, each containing 2 grains, should be given thrice daily when a rheumatic aetiology exists, but if active rheumatic carditis is present before the age of twenty a smaller dose should be administered; in pericarditis following pneumonia or empyema the dose should not exceed 2 grains twice a day, or alternatively 10 minims of tincture of digitalis should be given four times a day. If oedema is present the fluid intake should be restricted to 30 ounces daily, this quantity being varied according to the degree of fever and sweating present.

(b) Paracentesis

Paracentesis of the pericardium is called for in several circumstances: first and most urgently, when the underlying cause is not necessarily fatal and it is necessary to tide the patient over the circulatory embarrassment until such time as the pericardial inflammation has subsided; secondly, when effusion in the pericardium is believed to be purulent, since removal of the pus then offers the only means of saving life; thirdly, in order to determine the exact nature of the effusion.

The technique of paracentesis is the same in all cases, but there are several sites at which the puncture may be made. Except in the case of pericardial effusion known or believed to be purulent, the point chosen is usually below and external to the apex beat, but within the area of cardiac dullness. Such a spot is not usually difficult to choose. Alternatively, when the signs below the angle of the left scapula suggest that much fluid is compressing the lung behind the heart, paracentesis may

be made posteriorly, the needle being passed through the lung to reach the pericardial sac. Points close to one or other border of the sternum are sometimes advocated; these have the advantage of avoiding puncture of the pleural cavity and should therefore be specially considered if pneumonia or general infection is responsible for the pericardial inflammation.

*Insertion of
needle*

For the operation it is best to use a needle at least three inches long. The needle should be sharp, and careful infiltration of the skin and deep tissues with 2 per cent procaine hydrochloride (novocain) solution should be carried out in order to spare a very ill patient unnecessary pain. In paracentesis at the apex the needle is introduced perpendicularly to the skin and directed inwards and backwards towards the spine. The pericardium is reached and entered at a depth depending on the thickness of the chest wall, usually about one and a half inches. A puncture would be made in this position for the relief of pressure and the ordinary aspirating bottle and evacuating pump would then be employed to remove the fluid. Posterior paracentesis might be undertaken typically in rheumatic cases, and this approach offers the special advantage that the patient is able to assume the comfortable forward-leaning position while the aspiration is being performed.

*Technique
for purulent
effusions*

In purulent pericarditis, or when it appears possible that the exudate may be purulent, paracentesis must leave the pleural sacs intact. The best approach is therefore high in the angle between the xiphisternum and the costal cartilage on the left side, the needle being introduced at first perpendicularly and then directed sharply upward to enter the pericardium at its reflection from the anterior wall of the chest on to the upper aspect of the diaphragm. As this procedure requires familiarity with the anatomy of the region explored, and as in such purulent inflammation open operation on the pericardium is required for free drainage, both procedures are generally best left to the surgeon. An alternative site in purulent effusion is close to the left border of the sternum. This meets the requirement of avoiding pleural or lung puncture, but has the disadvantage that the heart, even when much fluid is present, may be very close to the parietal layer of pericardium, thus rendering aspiration difficult or even impossible without risk of injury to the heart or coronary vessels.

*After-
treatment*

In general, and especially if the common apical site is chosen, paracentesis of the pericardium is an operation that is no more difficult and scarcely more hazardous than pleural puncture. Aspiration of fluid brings great relief to the patient, and also results in immediate objective improvement. The fluid should be removed slowly, and an injection of morphine should subsequently be given. If the patient recovers from acute inflammation of the pericardium, a careful investigation should be made for the source of infection if this is not already known. At a suitable interval removal of tonsils or teeth or the eradication of other septic foci may be undertaken. Convalescence

should be gradual, the patient being kept in bed for at least a month after all signs of effusion and inflammatory reaction have cleared up.

(3)—Treatment of Chronic Adhesive Pericarditis

The two original operations for the relief of chronic pericardial adhesions were Delorme's (1898) and Brauer's (1903). Delorme's method was designed to free the heart from its constricting pericardium by dissection of the thickened membrane. This method has been developed in recent years by Churchill, and White (1931) working with him has reported six cures by its use. The first stage of the operation is the removal, under ether anaesthesia, of the costal cartilages and bony terminations of the fourth, fifth, and sixth ribs on the left side together with resection of part of the left border of the sternum. When the pericardium has been freely exposed, the piecemeal excision of the dense fibrous and often calcified tissue is proceeded with. Care is taken not to free the right chambers before the apex has been relieved, in order to avoid engorgement of the pulmonary circulation. The operation requires exceptional operative skill, and even so it is sometimes impossible to avoid rupture of the thin walls of the right auricle or ventricle. Decortication, including the separation of constricting bands in the neighbourhood of the venae cavae and partial relief of the diaphragmatic surface of the heart, may be achieved in sufficient degree at one operation, but in some instances a second may be necessary. When the thoracic muscles and superficial tissues have been replaced, the patient is put to bed in an oxygen tent.

Delorme's operation

There is no doubt that the Delorme operation may effect a cure in Pick's disease. It should be restricted to patients who have chronic constrictive pericarditis but no other cardiac lesion; it should be performed only when the disease causes invalidism, yet should not be deferred so long that the poor condition of the patient may render the operation unduly dangerous.

Indications and contra-indications

Brauer's operation, namely cardiolysis, was planned for the relief of chronic mediastino-pericarditis. It consisted in the resection of the fourth, fifth, and sixth ribs on the left side as far as they overlay the heart. Removal of the pericardium was not attempted, the aim being to relieve the heart of part of its burden by cutting away resistant structures that had to be dragged inwards by every contraction of the heart. In short, it was designed to abolish the hampering effect of external pericardial adhesions.

Brauer's operation

Cases suitable for this operation are those in which external adhesions to the thoracic wall are undoubtedly present, as shown by systolic recession of the ribs followed by a diastolic rebound. Diastolic collapse of the cervical veins, severe thoracic pain, and respiratory distress with congestion are also often found in patients with disease of this type, and in them the Brauer operation may not only relieve urgent symptoms, but at times completely abolish congestive failure. It is obvious that this method cannot give any relief in pure chronic constrictive

Indications

pericarditis, in which no external adhesions exist. White has suggested that the Brauer operation should properly be referred to as 'thoracolysis', the term 'cardiolysis' being more appropriately applied to the Delorme operation.

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IV.—MYOCARDIUM DISEASES

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1.—AETIOLOGY

638.] Myocarditis is a very frequent complication of pyaemia and septicaemia. Rheumatic myocarditis is, however, the most serious form. Other acute infections causing myocarditis are diphtheria, enteric fever, scarlet fever, influenza, pneumonia, and rarely measles. Chronic inflammations that attack the myocardium are tuberculosis, syphilis, and the rare Fiedler's myocarditis. Parasitic infections include malaria, hydatid and taenia cysts, and trichiniasis. Degenerative myocarditis includes fatty degeneration, fatty infiltration, and the myocardial changes of beri-beri. Myocardial changes also result from tumours.

2.—MYOCARDITIS

(1)—Pyæmic and Septicæmic Forms

*Pyæmic
forms*

639.] Abscesses, usually small, are common in pyæmia; they may be single or scattered, sometimes following the course of one of the coronary arteries; they may take the form of a septic infarct and are easily identified post mortem either through the pericardium or from the endocardium. Haemorrhage may be seen in the periphery of some acute abscesses. The patient seldom lives long enough for healing to take place.

Clinically the cardiac symptoms and signs are incidents in the pyæmia. Breathlessness, rapid pulse, and dilatation of the left ventricle may be observed; and sometimes there may be heard a pericardial rub.

*Septicæmic
types*

Two common forms of septicæmia produce changes in the myocardium, the one resulting from infection by streptococci, especially hæmolytic streptococci, the other from infection by the anaerobic organisms such as *Clostridium welchii*; both occur frequently as terminal infections. The heart in both is flabby. The endocardium of one or more cavities and the intima of the aorta are stained by hæmoglobin. The mitral and tricuspid rings are dilated, and the muscular tissue is soft, buff coloured, and congested. The streptococcal type is seen in fulminating streptococcal septicæmia, as in puerperal sepsis. The *Cl. welchii* type is seen in intestinal obstruction, post-operative dilatation of the stomach, and paralytic ileus. It is usually associated with necrotic changes in the liver and hæmorrhages in the adrenal glands; in the early stages the liver cells are shrunken, but later there are necrotic areas which may contain gas.

Clinically the cardiac changes are manifested by breathlessness, a rapidly increasing pulse-rate, cyanosis, and dilatation of the heart.

(2)—Form associated with Acute Rheumatic Infection

*Morbid
anatomy*

The myocarditis of rheumatic fever may show very little alteration to the naked eye; the main changes are seen in the valves. The substance of the myocardium is paler than normal and may be in a condition of fatty degeneration. It may be possible to identify a little excess of fibrous tissue in the course of the vessels. If there has been a previous attack of rheumatic myocarditis, the substance of the papillary muscles may show here and there little streaks of fibrous tissue which are not normally present. Microscopically the cardiac muscle shows an increase of a reactionary fibrous tissue in the adventitia of the vessels, especially the small coronary arteries. Occasional sections may show an Aschoff body in the adventitia; this structure is usually spindle-shaped and at first sight suggests an epithelial tubercle, which it resembles in size. It consists of spindle cells of an irregular type. The other cells present are of the epithelioid type with large vesicular nuclei; two or more nuclei may be present in one cell. A few eosinophils and polymorpho-

*Aschoff
bodies*

nuclears may also be present. These bodies may be very difficult to find in obviously rheumatic infections, but rarely they may be abundant in every microscopical section. In addition there is a general increase in the fibrous tissue of the myocardium; in any case which has lasted some months the muscular fibres show an increase in size indicating hypertrophy. For the clinical features see p. 239; also RHEUMATIC INFECTION, ACUTE.

(3)—Forms associated with Diphtheria, etc.

In the early stages of diphtheria the heart may be affected by scattered patches of necrosis or of hyaline degeneration of the muscle which ultimately disappears with the deposition of fibrous tissue. The other and more common change is a generalized pallor of the myocardium, which by suitable reagents can be shown to be due to fatty degeneration. Microscopically the individual fibres are studded with numerous minute droplets of fat. It is this to which the more common cardiac failure of diphtheria is due. See also DIPHTHERIA, Vol. IV, p. 84.

In enteric fevers the cardiac muscle in the fatal cases may be flabby or may show little change to the naked eye. It often has a yellowish-brown tint with mottling. Histologically there may be parenchymatous degeneration and in the later stages increase of interstitial tissue; the muscle-fibres show hyaline degeneration and vacuolation. There is often abundant round-celled infiltration, and the arteries may show inflammatory hyperplasia. For the clinical features see ENTERIC FEVERS, Vol. V, p. 56.

In pneumonia and influenza cardiac, or at least circulatory, failure is a common termination. Neither to the naked eye nor histologically is there sufficient alteration of structure to account for it. Apart from some dilatation of the right side of the heart in pneumonia very little may be found amiss with the myocardium, and in influenza, even in the epidemic type, the myocardium is not grossly abnormal. For the clinical features see INFLUENZA, and PNEUMONIA, LOBAR.

(4)—Other Forms

Affections of the myocardium associated with tuberculosis, syphilis, parasites, and tumours are discussed later.

In beri-beri the heart is dilated, especially the right side; microscopical examination shows oedema and fatty degeneration. See also BERI-BERI, Vol. II, pp. 315 and 317.

Fiedler's myocarditis is a condition of unknown aetiology. It occurs in young adults up to the third decade and is associated with embolic manifestations, pulmonary or cerebral, which are followed by progressive myocardial failure, often very rapid, and may occur as early as the period between the seventh and fifteenth days. The cavities of the heart are dilated. The endocardium is not affected, but the pericardium may be opaque from fibrous tissue; the myocardium shows disseminated patches and round-celled infiltration with destruction of

the muscle-fibres. In the later changes these patches are replaced by fibrous tissue.

*Clinical
features*

Clinically, Fiedler's myocarditis is characterized by rapid cardiac failure with breathlessness, cyanosis, and tachycardia; in those who live longer the picture is one of congestive cardiac failure.

(5)—Degenerations of the Myocardium

The common lesions of this type are fatty degeneration and fatty infiltration. Fatty degeneration is seen in diphtheria, pernicious and other severe anaemias, and occasionally in intoxications, such as arsenical or alcoholic. The heart is pale because its muscular fibres are filled with minute fatty globules. The endocardium may show the thrush's-breast phenomenon. Fatty infiltration, which occasionally gives rise to myocardial weakness, is seen usually, if not exclusively, in excessively obese subjects. It is also common in the subjects of gall-bladder infections. Here the normal epicardial fat penetrates more deeply into the myocardium along the connective-tissue septa and vessels; in severe cases it is seen under the endocardium and may take the place of large sections of the muscular tissue.

The clinical features consist in general enfeeblement with low blood-pressure and breathlessness on exertion; occasionally there are mental symptoms. The ordinary signs of congestive cardiac failure are minimal.

(6)—Syphilitic Affections of the Myocardium

*Morbid
anatomy*

There are several different forms of syphilitic affection of the myocardium, but they all depend in their essential features on chronic inflammation of the vessels, chiefly the arteries. All three coats of the arteries may be affected, resulting in either narrowing or blockage of the lumen, thrombosis, or weakening and aneurysmal dilatation.

The recognizable lesions are:

Gumma

(1) Gumma: a portion of the wall of the ventricles or septum undergoes necrosis and becomes surrounded ultimately by a zone of fibrous tissue which gradually takes the place of the necrotic heart wall. The left ventricle is the part chiefly attacked and the gummata may be multiple. When they occupy the positions usually seen in coronary thrombosis they may be difficult to distinguish anatomically from that disease; as a rule, however, the portions of ventricle affected are irregular and do not correspond to the accepted patterns of anterior or posterior coronary artery occlusion. The commonest stage in which gummata are seen post mortem is that of a fibrous patch or patches which have destroyed the muscle at the site.

*Syphilitic
arteritis*

(2) Syphilitic arteritis of one of the main coronary arteries with gradual narrowing or obliteration of the lumen: a common site is a centimetre or so from the origin of the artery from the aorta. In this event the resulting ischaemic necrosis cannot be distinguished by the naked eye from the non-syphilitic form, unless the affected artery shows distinctive change, such as much periarteritis or aneurysmal dilatation.

(3) Aneurysmal dilatation: this may be single in the first half-inch of a coronary artery or multiple along the smaller branches. The large aneurysms may burst and produce a haemopericardium; the smaller aneurysms are more commonly associated with local or peripheral changes. *Aneurysmal dilatation*

(1) Death may be sudden without any previous warning or may occur after a period of cardiac symptoms. It is usually the result of a ruptured aneurysm. It may, however, occur in gross disease of the myocardium. Sudden death from this cause has been reported by Laves as early as six months after the initial infection. *Clinical picture*

(2) In about a quarter of the cases in which syphilis attacks the heart there is a history of cardiac symptoms which cannot be explained by the valvular change. This form is chiefly the result of gummatous myocarditis. A patient in early middle life who has perhaps engaged in athletics, who has not had rheumatism, and is too young for coronary thrombosis, begins to suffer from shortness of breath. Such a person, especially if a male, should be strongly suspected of syphilis (Coombs). The onset is slow and the condition usually progresses towards cardiac failure. Treatment as a rule restores some measure of cardiac reserve, but after a time there is a relapse, and a fatal issue is seldom delayed beyond the third attack of decompensation. The patient may also complain of palpitation and expectoration. The picture is one of cardiac failure without any obvious cause. The heart is usually enlarged both to the right and to the left. A systolic murmur is commonly present at the apex and a diastolic murmur may be heard at the base, though from first to last murmurs may be absent. When present the murmurs are due to dilatation of the mitral and aortic rings respectively; they may disappear with treatment, and in some recorded cases of aortic regurgitation the aortic valve leaflets have been found normal at the necropsy. In the course of the disease the first sound deteriorates and there may be a gallop rhythm. *Physical signs*

(3) Other cases show anginal symptoms, sometimes the angina of effort and sometimes spasmodic angina. *Anginal symptoms*

(4) Arrhythmias, especially heart block, fibrillation, and bundle-branch block, are also sometimes seen. *Arrhythmias*

The age of the patient and the absence of other causes of cardiac disease are important diagnostic indications of syphilis. The high incidence in males should also be remembered. Adolescents with congenital syphilis are not exempt from cardiac complications. Coombs referred to the importance of otherwise negligible cardiac symptoms and signs in those who are known to have had syphilis. A thorough search for syphilitic stigmata should be made and the blood examined for the Wassermann reaction. The electrocardiogram may reveal slight irregularities, such as a tendency to negativity of the T-wave in lead I, and it has been stated that a notch on the ascending limb of the R-wave should be looked upon as suggestive. In view, however, of the variation in the site of a syphilitic lesion any abnormality of the electrocardiogram should be regarded as of possible significance. *Diagnosis*

Prognosis

The outlook is invariably serious in the presence of breathlessness and a tendency to cardiac failure. According to Coombs 50 per cent of all patients with cardiac syphilis die within four years of coming under observation. When there has not been any cardiac failure, such as in those with anginal symptoms and arrhythmia, thorough treatment may cure the symptoms and leave the patient with a better outlook.

Treatment

If the patient comes under observation with cardiac decompensation, the treatment should be that for cardiac failure, with rest in bed, full digitalization, and restriction of food and drink. The obstinate cases with oedema may need treatment with one of the mercury diuretics, for example injection of mersalyl (salyrgan), 2 c.c. intravenously every fourth day. As the patient recovers from cardiac failure, a full course of antisyphilitic treatment should be given, including a course of six weekly doses of arsphenamine followed by a course of mercury and iodide. If the syphilitic disease is judged to be extensive, it would be prudent to begin with a dose of 0.1 gram of arsphenamine and gradually increase to 0.45 gram for the later doses. A course of arsphenamine should be given every six months with courses of mercury and iodide intervening. In addition the patient's life should be regulated, his activities limited to what the heart is likely to stand, and any excess in eating or drinking corrected.

(7)—Tuberculous Affections of the Myocardium*Morbid anatomy*

Tuberculosis affects the myocardium either through the blood-stream or by direct extension of tuberculous disease from the glands of the mediastinum. In miliary tuberculosis it is not uncommon to find a few scattered tubercles on the septal wall of the right ventricle towards the conus; in patients who have survived longer, tuberculous lesions of various sizes are seen in relation to the coronary vessels, a type described as nodular. The arteries or veins may be eroded and replaced by granulation tissue and there may be thrombosis. In a second type caseous foci with surrounding granulation tissue are present in the auricular walls. In a third type the heart walls may be gradually infiltrated as from a pericarditis. A fourth type is also described of general tuberculous myocarditis which includes sclerosis.

Clinical picture

(1) The disease may be silent; in this event it may be discovered accidentally in a patient who has died of tuberculosis of some other organ, or when death occurs unexpectedly, as under an anaesthetic.

(2) In its usual form it produces a slow diminution of cardiac reserve which, if the patient lives long enough, produces signs of cardiac failure of the congestive type.

Diagnosis

The diagnosis is seldom made during life unless there is some well marked tuberculous lesion elsewhere. When the possibility of tuberculosis of the myocardium is suspected the presence of fibrillation, extrasystoles, and other irregularities such as pulsus alternans is important. An electrocardiogram should therefore be taken if the lesion is suspected.

(8)—Parasitic Diseases affecting the Myocardium

In the serious forms of malarial infection there occurs a dilatation of the heart associated with a fatty degeneration of the heart muscle-fibres. *Aetiology and morbid anatomy*

In Chagas' disease, South American trypanosomiasis (see Vol. III, p. 91), the heart may be enlarged and the myocardium infiltrated with cellular exudate.

The parasitic worms that may affect the heart are hydatid cysts (*Taenia echinococcus*), very rarely cysticercus cellulosae (*Taenia solium*), and, in a proportion of cases, *Trichinella spiralis*. (See also CYSTICERCOSIS, Vol. III, p. 523, HYDATID DISEASE, p. 561, and TRICHINIASIS.) The heart may be pressed upon by hydatid cysts in the mediastinum or pericardium or its action may be interfered with by cysts actually in the cardiac walls or septum. They may be found in the early cystic stage or degenerate and hard. Tumours the size of a goose's egg have been found in the intraventricular septum.

In trichiniasis the myocardium may show scattered microscopic areas of infiltration with polymorphonuclear and eosinophil cells along the course of the small vessels. Fibrosis may be seen later. Special methods must be adopted to isolate the *Trichinella*.

In malaria there may be syncopal attacks or cardiac failure with breathlessness and oedema. Patients with Chagas' disease suffer from general enfeeblement of the heart and often die suddenly. The rhythm may be unaltered, though tachycardia, bradycardia, and auricular fibrillation are described in patients with the disease. *Clinical picture*

In hydatid disease of the myocardium symptoms may be absent and the condition only discovered accidentally after death. Death, however, may be sudden, either by the production of cardiac arrest or ventricular fibrillation, or by an obstruction to the circulation by rupture of the cyst. Symptoms of valvular disease may arise if the position of the tumour is in relation to one of the orifices. The patient suffers from increasing dyspnoea and cyanosis as the cardiac failure progresses. The heart both clinically and radiologically is enlarged.

3.—MYOCARDIAL CHANGES RESULTING FROM TUMOURS OF THE HEART

640.] Tumours of the heart may be primary or secondary. Of the primary tumours less than 200 have been recorded, and of these about half have been myxomatous. Some authors look upon these myxomas as representing degenerating forms of organized thrombi rather than true neoplasms, but the absence of any layer formation and the absence in most cases of any source of a thrombus point to their being tumours rather than thrombi. Secondary tumours are not uncommon, and metastases in the heart have occurred from tumours of all the *Aetiology and morbid anatomy*

principal organs of the body, though they are more common in malignant disease of the lung, pleura, or mediastinal glands. In these cases the pericardium may be heavily infiltrated, leaving the heart unaffected. The primary tumours are more commonly benign though the myxomas sometimes show malignant tendencies. Myxomas of the heart arise more commonly in the left auricle and they have a tendency to interfere with the blood-flow through the mitral valve. They may be as small as a pea or so large as almost to fill the cavity. Thrombi may form to some extent on their surface, from which emboli may be detached. Other rarer forms of tumours of the heart are fibromas, rhabdomyomas (see Vol. V, p. 121), and endotheliomas.

Clinical picture

The symptoms recorded in the cases of pedunculated tumours arising in the left auricle are palpitation and pain in the region of the heart. Symptoms occur in attacks and are seldom related to exertion. Oedema of the lower limbs occurs and dyspnoea out of proportion to other physical signs. Fainting spells which mimic Adams-Stokes disease have also been described. Of physical signs a presystolic murmur, though rare, should be listened for, the tendency of the tumour being to impede the blood through the auriculo-ventricular orifice. This presystolic murmur may vary in intensity with changes of posture and may in some postures be replaced by a systolic murmur. Again a blowing systolic murmur may be heard and in this instance the first sound at the apex may be unusually loud and drumming in character.

Physical signs

In a case recorded by Gilchrist and Millar the patient had peculiar respiratory difficulties, a respiratory arrhythmia with short attacks of dyspnoea occurring when lying on the back. These simulated paroxysmal nocturnal dyspnoea but in this instance were probably due to the temporary blockage of some of the pulmonary veins. These attacks of breathlessness were out of proportion to the other signs of heart failure and were often preceded by submammary pain which was the first symptom.

Symptoms of secondary invasion

In secondary neoplastic invasion of the heart the symptoms are related more commonly, in the initial stages, to the pericardium; furthermore they produce evidence of cardiac failure with or without interference with the normal rhythm. Electrocardiograms have been normal in a proportion of the recorded cases. Partial heart block is produced when the region of the auriculo-ventricular node is invaded. When the auricles are invaded, as in the case described by Gilchrist and Millar, arrhythmias are more likely to occur. In these cases there are attacks of paroxysmal auricular tachycardia. When tumours attack the ventricular muscle, there may be extensive involvement without interference with the regularity of the beat.

Diagnosis

Primary tumours of the heart are so rare that it is not surprising that there appears to be no instance in the literature in which a diagnosis has been made during life and subsequently confirmed at necropsy. Secondary tumours, however, are occasionally diagnosed when the sudden appearance of circulatory symptoms in a patient with a tumour elsewhere suggests a metastatic invasion. The development of an

arrhythmia, the appearance of a pericardial effusion, especially if blood-stained, or a localized patch of friction, or even venous stasis with congestive heart failure may provide a clue to the affection of the heart in these circumstances. Any alteration in cardiac rhythm, such as heart block, should direct attention to the heart when there is a tumour elsewhere.

The course is inevitably downwards and no case of recovery has been recorded, though in some of the pedunculated tumours, if a diagnosis could be made in life with accuracy, a bold surgical technique might be successful. *Course and prognosis*

4.—STAB WOUNDS OF THE HEART

641.] Wounds are most often due to knives, but may be due to smaller instruments such as a needle. Bullet wounds are also important. The site is more commonly on the anterior surface; the wound may be linear or punctured, and the immediate effect is to produce a haemopericardium. This distension of the pericardial sac causes sudden failure of the heart and gradual diminution in arterial pulsation. Recovery is possible from a small degree of haemorrhage with gradual organization of the clot and formation of a much thickened pericardium. The pleura is occasionally wounded and the lung collapsed. If asepsis has been preserved small portions of the pericardial sac may remain. High degrees of haemopericardium inevitably lead to death. *Morbid anatomy*

If operation is undertaken for the relief of the pressure in the pericardium and the patient lives, the danger lies in the sepsis that frequently follows. The pericardial layers are thickened by granulation tissue; they are adherent to each other over large parts of their surface, leaving a few intercommunicating loculi. The pumping action of the heart with an open pericardium leads almost inevitably to a septic pericarditis. Strong solutions used for perfusing the pericardium may also cause great thickening by granulation tissue. C. S. Beck reported that a surgical solution of chlorinated soda injected into the pericardial sac of dogs produced polyserositis sometimes with oedema. Chronic sepsis of the pericardial sac leads similarly to polyserositis with great thickening of the pericardium, enlarged liver, ascites, and generalized oedema. The organisms responsible for the septic pericarditis are streptococci and staphylococci. Aneurysm of the left ventricle of the heart following stab wounds has been described by Brunetti. *Late results*

The initial effect of a stab wound is to produce, after some seconds or minutes, collapse during which consciousness is diminished or lost; there is some cyanosis of the lips and finger-tips and the skin is cold and clammy. The heart's action is barely perceptible either in the palpable arteries or on auscultation. When operation is undertaken, following a period of shock, there occurs a condition of chronic pericarditis with fever and the gradual development of Pick's syndrome *Septic pericarditis*
Clinical picture

with ascites and generalized oedema. If the patient recovers from the sepsis the heart's action is usually restored to normal. Later results reported are precordial pain sometimes with dyspnoea. In cases in which the wound is not completely closed, as from a bullet, there may be slight pericardial haemorrhage on exertion, shown by dizziness, faintness, and tachycardia.

*Electro-
cardiogram*

The electrocardiographic changes are on the whole slight and wounds of the larger coronary vessels do not appear to make much difference. There is a rise in the take-off of the T-wave with a gradual return to the isoelectric line accompanied by inversion of the T-wave within ten days. In the majority of cases there is a return to the normal curve.

*Course and
prognosis*

Wounds of the heart by foreign bodies are not necessarily fatal; a patient may survive the presence of a bullet embedded in the heart for many years.

In any severe case in which pericarditis is established the course is long and difficult. The patient may be extremely ill both from sepsis and from the constricting action of the pericardial healing. Death may occur at any time. According to Hesse's figures 77.3 per cent of patients survived the operation with complete restitution of function; in 22.7 per cent there were fair results, and 1.7 per cent were disabled. Adhesive pericarditis and mediastinitis may result in death from cardiac insufficiency.

*Diagnosis
and
treatment*

The decision whether or not to operate in cases of wounds of the chest which may involve the heart depends on the presence or absence of acute cardiac failure with cyanosis. The decision may have to be taken quickly. In the circumstances preparations cannot be adequate. The loss of blood is often considerable and needs restitution by transfusion after the suture of the wound of the heart.

*Methods of
exposing
heart*

The heart may be exposed: (i) by enlarging the wound and cutting through the injured sternum or costal cartilages with bone forceps; (ii) by making an incision by the left of the sternum and along the lower ribs, and the cartilages of the 4th, 5th, 6th, and 7th ribs; or (iii) by splitting the lower half of the sternum and holding the halves aside.

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V.—ENDOCARDITIS, NON-MALIGNANT

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(*Synonyms*.—Inflammation of the endocardium; valvulitis; endocardial sclerosis; valvular sclerosis)

1.—SIMPLE ACUTE

(1)—Definition

642.] The term simple acute endocarditis indicates an acute or subacute inflammation of the valves or other part of the endocardium; with the formation of small clustered vegetations which disappear, leading to thickening or further changes in the valves.

(2)—Aetiology

Simple endocarditis is most frequently seen in acute rheumatic fever or chorea. Children suffer more often than adults from the endocarditis of rheumatic fever and the percentage of those affected by endocarditis may be as high as 80 per cent. Thayer's figures show that its highest incidence is in the second decade. It also follows scarlet fever and streptococcal sore-throat, especially that caused by *Streptococcus haemolyticus*. It is a rare sequel to measles, chicken-pox, diphtheria, smallpox, and enteric fever. Not uncommonly at a post-mortem examination, in such conditions as lobar pneumonia and tuberculosis, the valves show a recent endocarditis which was not suspected during life and was probably due to a terminal infection.

There can be no doubt that, as first maintained by Poynton and Paine, the cause has some intimate relation to the streptococcus; the fact that in some epidemics of sore-throat rheumatic fever occasionally follows after a lapse of ten to twenty-one days substantiates this view. A more modern conception is that the relation may be allergic, and that, although the streptococcus is an essential link, the disease is the result of sensitization.

Of predisposing causes the most important are (i) insanitary housing conditions, especially dampness, hence its prevalence in certain districts and among the poor, and (ii) a hereditary or familial tendency.

(3)—Morbid Anatomy of Rheumatic Endocarditis

In the earliest stage of simple rheumatic endocarditis the mitral valve is slightly more opaque than normal, and just above the edge of the valve curtains on the auricular face there appears a row of minute pin-head, buff-coloured, almost transparent granulations. They vary in size between 1 and 4 mm. and are sometimes clustered like the surface of a cauliflower. The line of granulations may follow the edge of one or both leaflets, or they may be attached to a small length only. The pressure of the contiguous valve surfaces may determine their appearance on these sites. Occasionally the granulations by the edge of the leaflets are entangled in the valvular attachments of the chordae tendineae. The granulations consist of fibrin and blood-platelets with a few cells but no organisms that can be identified. In the earliest stage the valve may be swollen and oedematous.

As the process advances the granulations become invaded by young fibrous tissue with a few vessels; later the granulations disappear by contraction and leave in their place a thickened margin of the valve, together with an opacity of the leaflets, a thickening of one or more of the chordae tendineae to three or four times their normal diameter, and the penetration into the papillary muscles of strands of fibrous tissue. This fibrous tissue is evidence that the rheumatic infection is always a myocardial as well as an endocardial affection. Inflammation may cease at an early stage and the valve may escape any shrinkage or

Incidence

Relation to streptococcal infections

Predisposing causes

Mitral valve: early changes

Later stages

mechanical defect. The damage, however, may be sufficient to produce a slight leak but no narrowing of the orifice.

*Detachment
of
granulations*

Alternatively, the granulations may be detached and form emboli large enough to block one of the middle cerebral arteries; or they may be invaded by organisms such as streptococci and produce malignant endocarditis; the process may also become chronic and cause massive thickening and deformation of the valve.

Aortic valves

When the rheumatic process attacks the aortic valves, there is a similar deposition of buff-coloured granulations, usually along the curved edge of the lunule, though they may also appear at the free edge of the cusps. Again, the process may cease with slight thickening of the valves and a slight enlargement of the nodules of the semilunar valves (*corpora Arantii*).

(4)—Clinical Picture

Symptoms

The rheumatic form may come on insidiously, especially in children. The patient becomes listless, shuns exertion, and may be breathless on slight effort. Neglected cases, especially in children, may even go on to congestive cardiac failure before coming under observation. These are symptoms of myocardial involvement. The patient may complain of thoracic pain from pericarditis. The early symptoms of a mild febrile ailment with moderate temperature and increase of pulse and respiration may accompany the other symptoms. The pulse is quicker than the temperature would suggest. Rheumatic pains and arthritis are present in a proportion of cases but not always. In bedridden patients endocarditis, especially a terminal endocarditis, may be unsuspected.

*Physical
signs*

The physical signs of endocarditis become obvious only when the myocardium is affected, and this is true in a recent primary attack or in a secondary attack of endocarditis with old changes in the valve which have set up compensatory alterations. The most obvious sign is pallor. It is not the pallor of anaemia, for there is no more than a slight secondary anaemia in these cases; moreover the pallor may vary according to the degree of cardiac disability. The tint sometimes suggests that of ivory. In advanced endocarditis the patient may be orthopnoeic and breathless, and when cardiac failure has set in the jugulars may be full, the liver enlarged, and the legs oedematous.

On inspection of the praecordia there is obvious pulsation, sometimes lifting up the sternum and ribs at each beat; the apex beat is diffuse and further to the left than normal. On palpation the heart is felt to be over-active and even tumultuous. The rate is raised and the rhythm is regular, at least in the primary attack. Percussion shows enlargement of the heart to the left and occasionally to the right of the sternum. If there has been pericardial effusion, the upper limit of cardiac dullness may extend to the second rib. Auscultation may discover pericardial friction, and a systolic murmur is present over a large area, though loudest at the apex. The first sound of the heart is lengthened; pre-systolic elements are not easy to detect in the early stages. The systolic

murmur in the presence of fever may be haemic and vary considerably with the phases of respiration; it may therefore include a cardio-respiratory element. The true mitral systolic murmur from organic change of the mitral valve is soft, rather difficult to hear, persistent through all phases of respiration, and traceable some distance into the axilla; there may also be a systolic murmur at the base. In the early stages diastolic murmurs at this area are difficult to identify.

A search for rheumatic nodules is successful in a large proportion of cases. They may be found on the occiput, over the shoulders where the bone lies near the surface, and on the elbows, wrists, flexor tendons, knees, and ankles. The discovery of such nodules confirms the rheumatic origin of the endocarditis. *Rheumatic nodules*

There is a slight secondary anaemia with a polymorphonuclear leucocytosis, and a trace of albumin is often found in the urine. *Blood and urine*

(5)—Diagnosis

Except in debilitated patients endocarditis produces fever, and changes in the pulse-rate and heart in excess of those produced by the grade of fever. The pulse-rate is more quickened and there may be a cardiac murmur, especially a systolic murmur conducted to the axilla and both in pitch and quality unlike the haemic murmur of fever. All systolic murmurs must be clearly distinguished from the cardio-respiratory murmur produced by rhythmical compression of the lung between the heart and the chest wall. The debility of the patient is always more than can be accounted for by the fever.

When the fever is persistent, especially if sweating is present, septicaemia may be suspected, and the disease may then have to be distinguished from tuberculosis, malignant endocarditis, the enteric fevers, and brucellosis. *Differential diagnosis*

(6)—Prognosis

From the evidence of necropsies it is clear that many persons pass through a mild attack of endocarditis without damage to the heart; clinical evidence shows that a patient may recover from a severe or dangerous endocarditis with such good compensation as to enable him to lead an ordinary or even an arduous life.

The ultimate effect depends in large part on the valve or valves affected. Mitral regurgitation has the best outlook, followed in descending order by aortic regurgitation, aortic stenosis, mitral stenosis, and combined lesions. *Valves affected*

Acute endocarditis is very occasionally fatal in the first attack from implication of the pericardium, or from severe myocarditis with congestive failure, pleurisy, or pneumonia; but, especially in the young, recovery may follow severe pancarditis even with heart failure. The patient may suffer from one attack of rheumatic endocarditis with a slight or severe damage to a valve. The most serious condition is produced from recurrent attacks of endocarditis, each attack adding its *Complications*
Recurrent attacks

quent to the damage of the valve. In those with badly damaged valves, non-rheumatic infections such as colds or bronchitis are liable to cause prolonged ill health, sometimes with a failure of compensation. Some patients appear to be prone to bacterial infections which settle on the damaged valves.

(7)—Treatment

The prophylaxis, general and local treatment, and after-treatment of simple acute endocarditis follow the lines discussed in the section on RHEUMATIC HEART DISEASE IN CHILDREN (see p. 250).

2.—CHRONIC

(1)—Aetiology

*Rheumatic
endocarditis*

643.] Chronic endocarditis is most often a sequel of acute endocarditis in childhood or adolescence, associated with repeated attacks of rheumatic fever or chorea, or following scarlet fever. These attacks, each accompanied by acute endocarditis, damage the valves step by step, or the rheumatic process never really dies down and the slow inflammatory process in the infected valve or valves produces fibrous tissue and contraction. The rheumatic affection of valves, though itself probably a specific chronic inflammation, may be intensified by intercurrent infections such as tonsillitis or bronchitis.

*Syphilitic
endocarditis*

Syphilitic endocarditis appears as a chronic process, several years after the primary sore, in men between the ages of thirty and fifty. It is not usually identifiable before thirty years of age and its progress is probably accelerated by strain. It is more often seen in men than in women, in whom it usually takes a more benign course though occasionally it is rapid. Syphilitic endocarditis is rare in congenital syphilis.

*Arterio-
sclerotic
endocarditis*

Arteriosclerotic endocarditis may arise from various causes, e.g. the wear and tear of life, lead poisoning, gout, chronic infections, and especially from chronic renal disease and high blood-pressure. The aortic and mitral valves undergo general thickening but this is seldom sufficiently marked to produce serious changes in cardiac action. A second form seen in later life is associated with calcification; calcified masses appear to invade the valves, aortic or mitral, and ultimately produce stenosis. This form is very slow in development, though the ultimate stenosis may be extreme; it is sometimes engrafted on a rheumatic endocarditis. A third form is a local mural endocarditis from implication of small arterial twigs supplying the endocardium.

(2)—Morbid Anatomy

(a) *Rheumatic Endocarditis*

*Button-hole
opening of
mitral valve*

In the rheumatic type there is increasing thickening of the valve with subsequent contraction of the fibrous tissue laid down. In the mitral valve both cusps become opaque, and the leaflets adhere to one another at their bases with the result that the aperture is narrowed; ultimately,

in the course of months or years, the two leaflets may become a thick cartilage-like septum in which the opening is a mere slit admitting the tip only of the little finger. Looked at from above it has the appearance of a somewhat worn button-hole, hence the name 'button-hole' mitral. In other cases the valve may be in the shape of a funnel projecting into the left ventricle with a constricted outlet. On the ventricular aspect of the valve the chordae tendineae are seen to be shortened and thickened; in some instances the thickening is local and gives rise to spindle-shaped enlargements. The papillary muscles, instead of having a thin layer of fibrous tissue as a sort of cap, are permeated with fibrous strands and sometimes shaped like the sharpened tip of a lead pencil instead of a nipple.

Chronic rheumatic endocarditis of the aortic valves produces a thickening, opacity, and ultimately a contraction of the valve leaflets. This contraction interferes early with the efficiency of the valve and causes regurgitation. The leaflets may also adhere to each other, and produce stenosis in varying degree. In its most marked state a condition similar to mitral stenosis may result, the adhesion of the three leaflets forming a hard unresisting obstruction at the aortic orifice. In later life these adherent leaflets may become calcified wholly or in part, and the hollow of the valve together with the sinuses of Valsalva may be partially filled in with calcified excrescences. *Aortic valves*

Rheumatic endocarditis of the aortic valve is remarkable for the absence of the naked-eye change in the aorta above the valve, though some writers have identified Aschoff bodies in this situation. Occasionally there are a few flecks of fatty infiltration, and in marked degrees of aortic regurgitation there may be an aneurysmal dilatation of the first and second parts of the arch. This, however, is clearly distinguishable from syphilitic aneurysmal dilatations by the natural colour of the aorta. Frequently in high grades of aortic endocarditis there are patchy thickenings of the endocardium just below the valves, but in the pure case there are never any gross changes such as occur in malignant endocarditis. *Aorta*

The tricuspid valve is occasionally affected when those on the left side are attacked, but usually not otherwise. The process leads to various degrees of thickening, which may be local or general, and to retraction, adherence between cusps, and stenosis. At any period a valve thickened by chronic endocarditis may show the small cauliflower-like granulations of acute endocarditis, which may be a recrudescence of a true rheumatic inflammation or the effect of an intercurrent or terminal infection. Endocarditis of the infective or ulcerative type is frequently seen as a terminal infection in chronic endocarditis. *Tricuspid valve*

(b) *Syphilitic Endocarditis*

The commonest site of syphilitic endocarditis is the aortic valves. The earliest lesion is a gummatous mesaortitis in the first two inches of the ascending aorta. This lesion spreads round the circumference of the *Affecting aortic valves*

aorta and may form a distinct zone. The syphilitic process spreads downwards and involves the cusps of the valve. The first effect is a thickening of the edge of one or more leaflets, which can be easily felt when the edge of the valve is held between the finger and thumb. Later there occur thickening, contraction and, in the relaxed state, crumpling of the valve. Early in the affection there is aortic regurgitation. The valves may be so damaged that half their substance is destroyed. The mesaortitis may produce such dilatation of the aorta that the valve segments, even though normal, are unable to meet completely (i.e. relative incompetence). A further effect of syphilitic aortitis, when it invades one or both of the coronary arteries, is a narrowing of their orifice. The lumen of the artery further down is usually not narrowed.

*Affecting
endocardium*

The second form of chronic syphilitic endocarditis is seen when the process attacks the endocardium covering the muscular wall. The endocardium, more commonly of the left ventricle, is raised up in the form of a flat projection constituting a gummatous infiltration. In some instances these patches may be difficult to distinguish from the grosser effects of coronary thrombosis. In other instances the opacities may be flush with the normal part of the endocardium and in this form represent a later and healed stage.

*Affecting
other valves
and
myocardium*

Syphilitic disease of the mitral, tricuspid, and pulmonary valves, if it occurs at all, is excessively rare; it is usually part of a gummatous process originating in the myocardium.

(c) Arteriosclerotic Endocarditis

Opaque yellow patches of thickening, especially in the anterior leaflet of the mitral valve, are commonly seen post mortem; they have no clinical significance and do not produce any other demonstrable changes in structure. The mitral valves become slightly thickened with advancing years, and in old, usually male, persons who have led arduous lives there may be a dense sclerosis at the tips of the papillary muscles. In the aortic valves there is a slight gradual thickening as the result of circulatory wear and tear. In this thickening the nodules of the semilunar valves (*corpora Arantii*) may partake in a special degree, and become markedly enlarged. Such thickenings may be sufficient to account for the systolic murmurs that may be commonly heard in older patients. They do not appear to produce any consequent disability on any other cardiac structure.

*Thickening
with
calcification*

A special form of arteriosclerotic thickening with calcification affects the aortic and more rarely the mitral valves. This thickening may occur in valves previously normal or in valves which have been damaged by rheumatic endocarditis. The calcification spreads from the attachment into the substance of the valves, and in a moderate example there are wart-like calcifications projecting from the valve surface chiefly towards the aorta. There may also be adhesions between the cusps and a slight general thickening of the valve substance. Calcification progressing towards the lumen and stiffening the leaflets offers an

obstruction to the onflow of blood from the ventricle to the aorta and prevents the valves from moving normally. The valve leaflets may be so thickened that, seen from the direction of the aorta, the opening is reduced to a tri-radiate chink. In the late stages, in addition to stenosis there may be regurgitation. In the rare case in which this form of calcification invades the mitral valve, mitral stenosis is the result.

(3)—Clinical Picture

The symptoms and physical signs are described in the articles dealing with the various valvular diseases. In the syphilitic and arteriosclerotic form that attacks the ventricular endocardium apart from the valves the symptoms are negligible until the myocardium is invaded; they are therefore discussed in the section on MYOCARDIUM DISEASES (see p. 281).

(4)—Course and Prognosis

Chronic rheumatic endocarditis may cease to be active at any stage, leaving a damaged valve or valves, the valvular inefficiency being compensated by hypertrophy. Compensation may be so perfect that an arduous life in good circumstances may not be harmful. Yet any patient with a damaged valve runs a greater risk during intercurrent infections; the organisms may become implanted upon the damaged valves and the myocardium may become less efficient. It may take weeks or months to recover from the illness; indeed in the more serious grades of valvular damage cardiac failure, which is inevitable in the later years of the patient's life, seems to be precipitated by such infections as colds, tonsillitis, or bronchitis.

*Rheumatic
endocarditis*

In syphilitic endocarditis the affection begins in the fourth or fifth decade and is always of the type associated with insufficiency of the left ventricle, namely, increasing dyspnoea. Cardiac pain may be present, the result of narrowing of the coronary arteries, but there is rarely any other symptom.

*Syphilitic
endocarditis*

In the arteriosclerotic form which occurs in the later decades of life compensation may be so efficient that there may not be any symptom beyond slight increasing breathlessness on exertion, which is looked upon as the result of advancing years. The course is very slow and several years may intervene before serious breathlessness may drive the patient to a doctor. Some of these patients die suddenly. The later course is gradual, towards congestive cardiac failure.

*Arterio-
sclerotic
endocarditis*

(5)—Treatment

The essentials of treatment can only be applied when the cause of the endocarditis is clear. Endocarditis alone is much less serious than endocarditis with myocarditis. In every form of myocardial insufficiency complete rest in bed is necessary, especially in the rheumatic variety or in the complications engrafted on it. No form of treatment beyond rest, good feeding, and absence of worry appears to have any marked effect.

*Rheumatic
form*

It is sometimes possible to nurse the patients in the open air, especially in summer, but in winter the possibility of chill must be guarded against and any appearance of rheumatic pains should be a signal for bringing the patient indoors.

*Syphilitic
form*

The first step in the treatment of syphilitic endocarditis is to remedy any myocardial insufficiency that may be present. Antisyphilitic remedies should then be applied—e.g. long courses of mercury and iodides, bismuth preparations, or mercurial inunction—and later carefully graded doses of one of the arsphenamine derivatives, e.g. neoarsphenamine, beginning with a small dose such as 0.1 gram. Further injections should be given at intervals of several days, the dose being gradually raised to 0.6 gram. After twelve doses have been given an interval of at least three months should elapse before a further course is undertaken.

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VI.—ENDOCARDITIS, MALIGNANT

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1.—DEFINITION

644.] Under the terms malignant, ulcerative, or bacterial endocarditis are included a number of forms of infection of the heart. Horder (1909) from an analysis of 150 cases described three forms: acute, subacute, and chronic, with two secondary forms—acute fulminating and chronic latent. Although there is no absolute line of distinction between them, there are two types which both clinically and bacteriologically are sufficiently distinctive to warrant separate description: (1) subacute bacterial endocarditis, and (2) acute bacterial endocarditis.

2.—SUBACUTE BACTERIAL ENDOCARDITIS

645.] Of the two types this is much the more frequent. It appears in the literature under a number of other names, such as chronic streptococcal

Synonyms

endocarditis, endocarditis lenta, chronic ulcerative endocarditis, subacute streptococcal endocarditis and influenzal endocarditis.

The great majority of the cases of bacterial endocarditis either run an acute course terminating fatally in a few days to a few weeks or else run a much more prolonged course of several months up to, in exceptional cases, two and a half years. There is fairly general agreement that any case lasting more than three months may be classed as subacute.

(1)—Aetiology

Frequency

In practically all cases subacute bacterial endocarditis develops in a heart the endocardium of which is already abnormal, most frequently on the basis of an old rheumatic endocarditis, less frequently in a syphilitic heart or a heart the subject of a congenital abnormality. Grant, in 1,000 cardiac army pensioners, followed for ten years, found 7 per cent affected with subacute bacterial endocarditis on the first examination, and a further 5 per cent developed the disease in the course of ten years. Libman (1925) stated that 0.3 per cent of patients with chronic valvular disease died of subacute bacterial endocarditis. About one-third of the subjects of congenital heart disease who reach adolescence also die of this condition.

Age and sex incidence

The sexes are almost equally affected; but after the War (1914-18) its incidence in males was very much higher than in females (Cotton; Coombs), and some authors estimate that males and females are affected in the proportion of 3 to 2. The main incidence of the disease falls between the ages of eleven and forty and about 86 per cent between the ages of eleven and fifty. A possible portal of entry of the infecting organism can be found in about 20 per cent of the cases, most frequently the teeth and tonsils. Some authors lay much stress on infection from the intestinal tract.

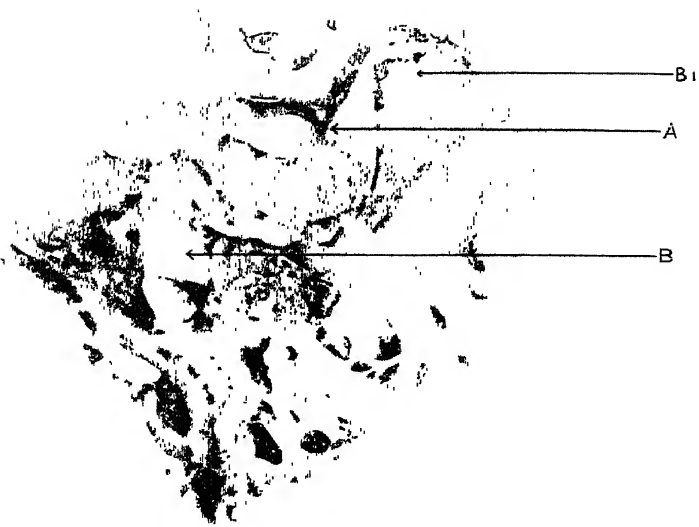
(2)—Bacteriology and Morbid Anatomy

Organisms

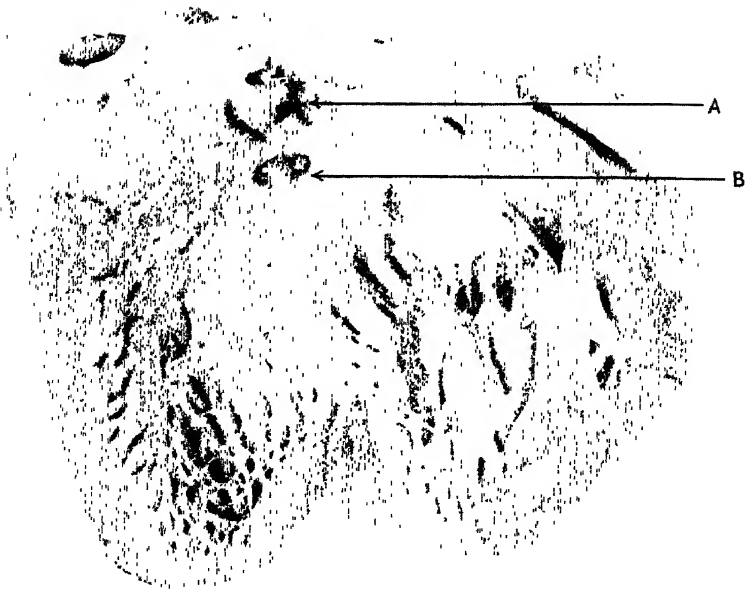
There are only two organisms of importance in subacute bacterial endocarditis. About 95 per cent of the cases are due to infection by the *Streptococcus viridans*, which Libman (1913) isolated in 73 out of 75 cases, and 5 per cent by the *Haemophilus influenzae*. Other organisms, such as staphylococci, pneumococci, and gonococci, have been reported in exceptional instances.

Morbid changes

Several outstanding points in the morbid changes are important in explaining the clinical symptoms: (i) Involvement of valves already damaged by previous endocarditis or congenital abnormality—hence the previous presence of various murmurs and enlargements. (ii) Involvement of the mural endocardium and chordae tendineae, which may rupture and lead to sudden changes in the character of murmurs. (iii) Relatively slight degree of involvement of the myocardium, which accounts for the absence in many cases of any great enlargement or signs of serious functional failure of the heart. (iv) Far lower incidence of pericarditis than in simple rheumatic infection of the heart. (v) A characteristic renal lesion—focal embolic nephritis—which



(i)



(ii)

Subacute bacterial endocarditis with congenital defect of the interventricular septum and chief incidence of vegetations on the right side. (i) Right ventricle. A, part of auriculo-ventricular cusp; B, auriculo-ventricular opening occupied by mass of vegetation; B₁, vegetation in region of septal defect. (ii) Left ventricle. A, vegetations on aortic cusps; B, septal defect showing part of vegetations seen in right ventricle

PLATE III

is characterized by the transformation of numerous glomeruli, wholly or in part, into homogeneous fibrous tissue (Löhlein: Baehr; Gaskell: Coombs). This lesion is manifested by the presence of blood and albumin in the urine but rarely leads to such functional failure of the kidneys as to produce uraemic symptoms. In a certain proportion of the cases, however, particularly the more chronic ones, there is an associated diffuse glomerulo-nephritis, which may lead to fatal uraemia.

The lesions in the heart, except when superimposed on congenital heart cases (see Plate III), are mainly confined to the left side of the heart, the mitral and aortic valves and the mural endocardium. They may be proliferative or destructive and in most cases are small; but very large cauliflower-like thrombotic vegetations, usually soft and friable, sometimes greenish in colour, may obstruct the valvular orifices. These vegetations characteristically extend along the endocardium from the mitral valve into the left auricle, and from the aortic valve segments, either by continuity or by 'kissing' contact, to the mural endocardium of the left ventricle; the chordae tendineae may thus become ulcerated and rupture. The myocardium otherwise shows little change and pericarditis is rare. The vegetations should be distinguished from those of the rare 'atypical verrucose endocarditis', which is not bacterial, but may, like other valvular lesions, become the site of subacute bacterial endocarditis (Libman and Sacks, 1924). This subject has been fully reviewed by Gross (1932). The friable vegetations, containing fibrin, platelets, and masses of bacteria, are a serious source of emboli, either minute and numerous, or larger and capable of blocking one of the larger arteries. Some of the lesions show a definite tendency to heal and become calcareous and in milder cases, according to Libman, may be completely arrested; but much more often the healing is incomplete and the condition progresses, or after a remission and a bacteria-free period it may relapse.

Plate III shows the appearance of the heart in a case of subacute bacterial endocarditis with congenital defect of the interventricular septum. The patient, a girl of sixteen, gave a doubtful history of rheumatism some years previously. The duration of her final illness was uncertain, but she was in hospital for six and a half months and ill some time before that. The lesions were most marked on the right side, where the auriculo-ventricular opening was occupied by a mass of vegetation, branching in and adherent to the whole of the right ventricle and to the septum in the region of the septal defect. In the left ventricle the vegetations were smaller and seen mainly on the aortic cusps.

The embolic lesions rarely suppurate. Toxaemia is shown in the usual way by cloudy swelling of the viscera, enlargement and infarction of the spleen, and so forth.

(3)—Clinical Picture

The clinical manifestations can be divided into two stages: (i) an early period in which the symptoms and signs are chiefly those of a low-

grade infection, and (ii) a late period when embolic phenomena, cardiac exhaustion, profound toxæmia, and more rarely serious anaemia or renal failure dominate the clinical picture.

Onset

The onset is usually insidious. The patient complains of general unfitness, undue fatigue, occasional chilly sensations, anorexia, fleeting pains about the muscles or joints, headache, insomnia, and perhaps some loss of weight.

In about 40 per cent the onset appears more acute either with acute febrile symptoms, such as chills and sweats, or with subacute joint symptoms, or some sudden embolic phenomena, such as hemiplegia and hæmaturia, or involvement of the right heart, cough, and hæmoptysis.

The general state of nutrition is at first little affected and may remain good throughout. In about 10 per cent emaciation becomes a prominent feature.

Pyrexia

Pyrexia is at some period of the disease probably invariable. Libman stated that a certain number of patients presented themselves with obvious sequelae of the disease, but without any history of the more acute stages, the bacterial infection having died out; they suffered from damage chiefly to the heart and kidneys, and in them pyrexia may never be observed. In the great majority of the cases, however, pyrexia is seen at some period. It is not usually very high and generally ranges between 99.5° and 102° F., rarely rising above 103° F. It may continue for months or there may be apyrexial periods with only an occasional rise for a few weeks at a time, or more rarely longer. It is generally remittent in type or may be quite irregular. Not infrequently it tends to fall towards the end. The fever may be accompanied by chills and sweating. Sweating may be profuse.

*Sweating**Cardiac
manifestations*

As the disease is practically always implanted on an already existing lesion, physical signs in the heart are already present. They may be obvious or they may be comparatively insignificant. In about 1 per cent of the cases murmurs are said to be absent throughout. They may remain unaltered for long periods and continue so even to the end. More frequently during the course of the disease such original murmurs tend to alter, or fresh murmurs may gradually or suddenly appear. The valves most frequently involved are the mitral, then mitral and aortic, more rarely the aortic alone. In cases supervening on congenital lesions the most frequent condition is a patent ductus arteriosus; the murmurs usually associated with the congenital lesions are present in these cases.

Arrhythmias apart from extrasystoles are uncommon, auricular fibrillation particularly so. Signs of pericarditis are quite unusual. Enlargement of the heart is generally present, but is often moderate and may be absent throughout. In the early stages cardiac symptoms are exceptional. Some palpitation is not infrequent and there may be slight dyspnoea. In the later stages the usual evidences of cardiac failure, generally of moderate degree, are not infrequent, and in almost one-third of the cases it is the main or an important contributory cause of

death. Cardiac pain varying from slight oppression to severe angina is present at some period in about 10 per cent.

The spleen can be palpated at some period in about 75 per cent of the cases. Most frequently the enlargement is moderate, up to one or two inches below the costal margin. Exceptionally the organ may be very large and extend well below the umbilicus. As a result of splenic infarction, paroxysmal pains may occur in the splenic area and occasionally a friction rub may be audible over it; the pain may suggest left-sided pleurisy. Enlargement of the lymph glands is not a part of the clinical picture. *Splenomegaly*

Cutaneous manifestations are frequent and important but may be entirely absent throughout. Anaemia with pallor is generally present, and occasionally is intense. In some of the more acute cases the face may appear flushed or cyanotic. In some chronic cases the so-called café-au-lait colour is at times notable. *Cutaneous manifestations*

Petechiae on both the skin and mucous membranes are frequent. They may be isolated, or numerous and in crops, particularly about the neck and shoulders. They are generally from 1 to 2 millimetres in size and should be repeatedly searched for or they may be overlooked. In a few cases more gross purpuric haemorrhages may develop. *Petechiae*

Osler's nodes—ephemeral painful nodular erythema—are said to be pathognomonic, but are often absent; they are practically limited to the fingers and toes and appear as painful slightly swollen red areas about half an inch in diameter often with a pale centre. They often appear in crops, last about twenty-four hours and leave a slight brownish pigmentation for a few days. Janeway's spots are small, non-tender haemorrhages which generally appear in the palms of the hands. Splinter haemorrhages producing linear haemorrhages with serrated edges below the nail are striking but rare. *Osler's nodes*

According to Cotton clubbing of the fingers is highly suggestive and develops in about 70 per cent. The toes may also share in the change. *Clubbing of fingers*

Embolic phenomena are extremely important and generally present at some stage, but they may be absent throughout. They include some of the skin changes mentioned, cerebral emboli, infarction of the kidney and spleen, and rarely embolism of the limb vessels. *Embolic phenomena*

The most important finding in the blood is the isolation by blood culture of the *Streptococcus viridans*, estimated to be present in from 80 to 90 per cent of cases. There may be either a moderate leucocytosis or exceptionally a leucopenia. The red cells generally show a moderate, but occasionally a very intense, hypochromic anaemia. *Blood changes*

Paroxysmal haematuria resulting from the embolic nephritis is an important symptom and in suspected cases the urine should be examined daily or it may be missed; it may, however, be absent throughout. Much stress has been laid on the presence of red blood-cells on microscopical examination of a centrifuged specimen of urine. Albumin may or may not be present. Renal failure is a terminal event in a small proportion of the cases. *Urinary changes*

Eye signs

Changes in the fundus oculi are frequent and valuable diagnostic signs. They include haemorrhages of various types in the retina, white spots, and occasionally marked neuro-retinitis. These changes may be permanent or transient. If looked for sufficiently often they may be found in at least 70 per cent of the cases and may be present when other symptoms and signs are few and indefinite.

Headache is frequent and may be severe. Cerebral emboli give rise to various forms of paralysis, which may be associated with a moderate pleocytosis in the spinal fluid. In exceptional cases, more definite signs of meningitis may appear.

Nervous symptoms

Transient muscle and joint pains are frequent; more definite arthritis occasionally occurs and exceptionally may dominate the clinical picture. Libman emphasized the frequency of sternal tenderness.

(4)—Course and Prognosis*Joint changes*

The disease, once fully manifested, nearly always ends in death at any period from three months up to a maximum of about two and a half years. About 2 to 3 per cent of the patients are said ultimately to recover; Libman (1933) has carefully analysed seventeen cases of recovery among his own patients, including one of fatal recurrence nine years after the original attack. In 281 cases analysed by Blumer, 75 per cent died within three to eight months of the appearance of clinical symptoms, nine lived over sixteen months, and six of those over two years.

The course is not necessarily steadily progressive; there may be periods of remission in which the fever disappears and the general condition improves so that the patient may be capable for some months of light work, but nearly always either the infective signs recur or the patient dies of progressive heart failure or uraemia. Libman insisted that a certain proportion of the cases lose all signs of infection and pass into a bacteria-free stage in which blood culture remains negative and in which the endocardium when examined after death fails to reveal bacteria and appears to be more or less perfectly healed. But even these cases generally prove fatal within the above-mentioned period, from the effects of the cardiac and renal lesions. Libman also believed that many mild cases with spontaneous recovery escape diagnosis. This may be so, but it does not alter the fact that, once the clinical picture is fully presented, the outlook is extremely grave.

The immediate cause of death may be: (i) cachexia and exhaustion aggravated by cardiac failure, which accounts for about 30 per cent or more of the cases; (ii) frank cardiac decompensation; (iii) embolism, mostly cerebral; (iv) uraemia; or (v) terminal infection, chiefly pulmonary.

(5)—Diagnosis and Differential Diagnosis

In the presence of the complete clinical picture, including persistent pyrexia, an increasing valvular lesion, repeated embolic phenomena, and a positive *S. viridans* blood culture, the diagnosis is obvious. But

in the early stages, and in some cases throughout the whole course of the disease, the clinical picture remains incomplete. Although a sudden hemiplegia may be the first symptom to draw the patient's attention to his condition, embolic phenomena on the whole are not early symptoms and isolated embolic phenomena may occur in a benign endocarditis.

A positive blood culture is important but not conclusive evidence: *Significance of blood culture*
transient *S. viridans* bacteraemia is not very rare apart from malignant endocarditis. To establish the presence of this condition in addition to the bacteraemia, it is necessary to have definite evidence of a progressive valvular lesion and embolic phenomena. On the other hand, cases can be confidently diagnosed in the absence of a positive blood culture. In specially favourable conditions a positive blood culture can probably be obtained in 80 to 90 per cent of the cases, but in less favourable circumstances the proportion of positive cultures may be much lower. Even repeated negative blood cultures do not exclude the disease.

The absence of serious signs of cardiac failure in the early stages is characteristic of the condition. Murmurs are nearly always present but not necessarily obtrusive. About 1 per cent are said never to show them. The significance of systolic murmurs is often indefinite; diastolic murmurs definitely indicate a valvular lesion, though not necessarily infective. *Signs of cardiac failure*

More significant is an obvious alteration in the character of a murmur already present or the development of new diastolic murmurs. Pericarditis is infrequent and in a child more suggestive of a rheumatic endocarditis. Auricular fibrillation or the development of conduction defects is also rare and suggests rheumatic carditis.

Splenomegaly is generally present but in some cases is never obvious. *Spleen*

Absence of leucocytosis is not a point against the diagnosis. Petechiae are important, particularly if they come in crops about the neck and shoulders, but they may occur in other conditions and may be absent throughout. *Leucocytosis*

Osler's nodes are said to be diagnostic, but in many cases they are absent throughout, and if there are only one or two nodes situated close to the nail it may be difficult to be certain of their exact nature. *Osler's nodes*

Splinter haemorrhages are very striking but also very rare. *Haemorrhages*

The development of clubbing of the fingers in a case of valvular disease previously free from it is highly suggestive, but this sign is present in only a minority of cases. *Clubbing*

The renal changes are diagnostically important, but are generally transient, and the urine must be frequently examined to detect them. A macroscopic haematuria is very significant. It is more difficult to assess the value of a few red blood-cells detected microscopically; nevertheless the urine should be centrifuged for the detection of red blood-corpuscles. *Renal changes*

The retinal changes are important chiefly because of their frequency and the fact that in many conditions likely to simulate subacute bacterial *Retinal changes*

endocarditis they do not occur. Also their discovery in a routine examination may be the first evidence of the implantation of a bacterial on a chronic endocarditis.

Pyrexia

Long-continued pyrexia is a cardinal symptom of the disease, but it may be of any type or absent for long periods. It not infrequently diminishes towards the end of the disease.

In the early stages, the variability of the symptoms, in the absence of any prolonged record of temperature, may lead to a diagnosis of functional disorder.

*Diagnosis
from other
fevers*

When the condition begins with a more acute febrile disturbance in patients already the subject of valvular disease of the heart, the shorter febrile diseases, such as influenza, enteric, malaria, and acute miliary tuberculosis, must first be excluded. The absence of embolic phenomena and a negative blood culture on the one hand, and the appearance of pathognomonic signs such as a positive agglutination reaction for enteric fever on the other, are important features.

In cases of pyrexia of longer duration, tuberculosis, brucellosis, lymphadenoma, concealed suppuration in the liver or elsewhere, and malignant disease with anaemia and prolonged pyrexia may all require consideration. The real difficulty occurs in cases in which such conditions occur in patients already the subject of chronic valvular disease.

*From
brucella
infections*

The exclusion of brucella infections may be very difficult, as they too are not infrequently characterized by palpitation, tachycardia, joint symptoms, and systolic murmurs. Positive agglutination to the infecting organism, e.g. *Br. melitensis*, even in relatively high dilutions is not trustworthy evidence; I have frequently had reports of complete agglutination up to 1 in 800 in cases of subacute bacterial endocarditis subsequently confirmed at necropsy. In the event of a negative blood culture to either condition and the absence of embolic phenomena, the most important differential feature is the blood count. A notable leucopenia with a relative lymphocytosis is almost invariable in brucellosis.

*From
rheumatic
carditis*

In children and young adolescents, particularly in the presence of joint symptoms, the differentiation between malignant endocarditis and a rheumatic carditis may be difficult for a long time. Pericarditis, auricular fibrillation, and evidences of heart block are rare in malignant endocarditis, but not uncommon in rheumatic carditis. Splenomegaly, Osler's nodes, the eye changes, and the renal manifestations are characteristic of the malignant form.

*From brain
abscess or
tumour*

In exceptional cases in which headache, mental confusion, and possibly focal nerve signs are present, including a pleocytosis of the spinal fluid, differentiation from brain abscess or brain tumour may for a time be difficult.

*From
anaemias*

In chronic cases the anaemia and splenomegaly may suggest a primary disease of the blood-forming organs, particularly so-called chronic splenic anaemia. The presence of diastolic murmurs, embolic pheno-

mena, and the results of blood culture are the chief differentiating points.

The acute haemolytic anaemia of Lederer may give rise to difficulties, but the anaemia is more severe, and the presence of active signs of regeneration, i.e. normoblasts and a high reticulocyte count, is in favour of haemolytic anaemia.

(6)—Treatment

So far there is not any treatment that materially influences the course of the disease. In such cases as do recover there is no evidence that the particular treatment adopted was responsible.

In view of the great gravity of the established disease it is essential that every effort should be made to prevent its establishment. The two important points in the aetiology of the condition are the presence of an already damaged endocardium and of the infective agent, and it is with these that prophylaxis is mainly concerned. Thus, it is highly important that every effort should be made to maintain persons known to have a damaged endocardium in the highest possible state of resistance. *Prophylaxis*

In many cases there is no obvious portal of entry for the infective agent, but when infective foci are present, particularly in the teeth, tonsils, nasal sinuses, and female genitalia, they should be dealt with as expeditiously as possible. This must be done, however, with the minimum of trauma to the affected tissues, otherwise the disease may be precipitated instead of prevented.

The patient should be at rest during the febrile periods, preferably in the open air if the conditions are suitable. During the afebrile periods the patient, if he feels fit, may be allowed up and about so long as he keeps within his exercise tolerance and avoids unreasonable exposure. Except in the unusual cases showing renal failure, the diet should be generous and rich in vitamin content. Milk, eggs, fresh fruit and vegetables, and good quality protein should form the basis of it. In some cases anorexia may be a prominent and troublesome symptom. Other symptoms should be treated as they arise. *General treatment*

There is not at present any reliable specific treatment. Autogenous vaccines have been extensively used with so far no real benefit. Transfusion with the blood of a donor previously immunized against the patient's streptococcus, combined with treatment by means of autogenous vaccines, has also been tried but without any convincing results. Stock antistreptococcal serum or specially prepared serum made by inoculating an animal with the patient's own organism has been tried in many cases, but without benefit. Autoserotherapy—the injection of the patient's own serum—has not given useful results. Repeated blood transfusions have been said to prolong life; on the other hand, the reactions following them may shorten it. *Specific Serum and vaccines*

Many drugs have been extensively used. Preparations of silver, e.g. colloidal silver, collargol, and electrargol, have been given by various *Chemical*

methods but without definite results. Arsphenamine, quinine, optochin, hexamine, and salicylates have also proved disappointing. Billings recommended sodium cacodylate in doses of 10 to 15 grains hypodermically every two to three days for a month with repetition of the treatment after a week's interval; the drug may also be given intravenously in 10 to 15 grain doses every two to three days for four doses and repeated after a week's intermission. Unfortunately his results have not been generally confirmed.

*Blood
antiseptics*

Many so-called blood antiseptics have been tried intravenously. Mercurochrome, acriflavine, gentian violet, and eusol have all been extensively tried, but without convincing results. Following mercurochrome it is not unusual to get a fall in the temperature which may persist for some days, and the patient may feel better. On the other hand the progress of the condition often seems to be accelerated, as shown by increased pyrexia and serious embolic phenomena. The same remarks apply to other members of this class; there is no evidence that any of them acts as a blood antiseptic.

At present it must be admitted that there is not any treatment which materially influences the disease and that the more energetic methods are not by any means free from the risk of aggravating the condition.

3.—ACUTE BACTERIAL ENDOCARDITIS

646.] As already mentioned there is no absolute sharp line of demarcation between some of the cases termed acute and some of those termed subacute. Many cases, however, run a much more rapid course and are the result of infection by a different group of organisms.

(1)—Aetiology

Frequency

In most clinics the acute type is much rarer than the subacute. Like the subacute it nearly always develops in an already abnormal endocardium. The proportion of cases with involvement of the right side of the heart is higher. Often the disease appears as a complication or of sequel to some acute infection such as pneumonia, osteomyelitis, puerperal or surgical sepsis, or gonorrhoea; more rarely, its appearance is apparently spontaneous.

(2)—Bacteriology and Morbid Anatomy

The chief organisms concerned are haemolytic streptococci, staphylococci, pneumococci, gonococci, and only occasionally *S. viridans*. Pathologically the lesions in the heart are more destructive and there is a greater tendency for the embolic phenomena to be associated with suppuration.

(3)—Clinical Picture

Symptoms

The symptoms may develop in association with some primary acute infection or apparently spontaneously. In cases occurring as a com-

plication of an acute infection, the initial infection may completely overshadow the symptoms of the cardiac involvement. When the acute bacterial endocarditis develops in a heart with damaged valves, murmurs are already present, and the only additional cardiac manifestations are the appearance of fresh murmurs or rapid changes in those already present, and the development of embolic symptoms.

In cases developing *de novo*, the condition usually sets in abruptly with symptoms very similar to those of the subacute form. The temperature range is higher, chills and rigors are more frequent, and purpuric manifestations are more prominent. The spleen is commonly enlarged. In the eye, embolism of the retinal artery is more frequent and involvement of the uveal tract or panophthalmitis may appear. The blood usually shows a definite polymorphonuclear leucocytosis, and the infecting organism can nearly always be recovered from the blood.

Gross embolic phenomena in the brain may lead to hemiplegia, and in the limbs to gangrene. The patient rapidly sinks into a typhoid state and in most cases dies within a few days or a few weeks.

(4)—Course and Prognosis

Curiously enough the prognosis, although extremely grave, seems rather better than in the subacute variety. It is best in gonococcal cases.

(5)—Diagnosis

The essential features are the presence of a septicaemic state, rapid changes in the physical signs of an endocardial lesion or the development of fresh murmurs, the occurrence of embolic phenomena, and the recovery of the infecting organism from the blood. The exact nature of the carditis may be suspected from the associated clinical conditions, but can only be definitely determined by positive blood culture.

(6)—Treatment

The treatment is on the same general lines as in the subacute variety. For some of the infecting organisms there are available more or less effective antisera, which may be used with rather more hope of success than the antisera prepared from *Streptococcus viridans*.

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VII.—MITRAL VALVE DISEASES

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1.—INTRODUCTION

647.] To define mitral disease and give a satisfactory explanation of the history of this malady, structural defect must be correlated with functional disorder; the cause of the lesion and its effect upon the health of the patient must also be known. The long controversy on the justifiable requirements for accurate diagnosis and prognosis, which has centred largely on the significance of murmurs and the mechanical effect of injury to the valve upon the functional efficiency of the heart, has not ended. With regard to the causation of mitral disease there is general agreement that the pathological processes which are responsible for injury to the valve are essentially those produced by the infective agent of rheumatism. *Causation*

An accurate diagnosis can be made on the basis of physical signs alone. The diagnostic criteria are cardiac murmurs which, from their character, position, and time, are interpreted as signs of obstruction or *Diagnostic signs*

of regurgitation. The signs of mitral stenosis are well defined and can be correlated with the underlying morbid changes with a measure of accuracy which renders them of the greatest value in diagnosis and treatment. The signs of mitral regurgitation lack this definition and precision, and are therefore less reliable evidence of the anatomical lesion or the functional defect.

A large part of the story of mitral disease, in so far as the valve is concerned, can be covered by a description of the natural history of mitral stenosis. It can be identified by distinctive morbid changes and physical signs, and studied in its different phases, as they succeed each other, by clinical methods of examination which are not difficult to apply. Its aetiological association with rheumatism has been established. The mechanical factors in their relation to the valvular deformity, and their effect on the propulsion of blood through the heart, can be assessed on a sound basis of anatomical accuracy. On the other hand, consideration of mitral regurgitation as a sign of mitral disease necessitates inclusion of certain variable quantities which cannot be measured by the signs upon which the diagnosis rests. The murmur, as an isolated sign of a valvular defect, may be confused with murmurs due to other causes. The character of the murmur does not bear any relation to the degree of regurgitation, nor does the absence of a murmur in certain circumstances exclude the diagnosis of a leaking valve. It is for these reasons that mitral stenosis should be placed in the foreground in the diagnosis of mitral disease and the management of the patient, whereas the consideration of signs of regurgitation should be kept in the background, for further reference if required, in the recognition of disease of this valve.

*Significance
of murmurs*

2.—MITRAL STENOSIS

(1)—Morbid Anatomy

*Inflammation
of rheumatic
origin*

648.] The origin and development of mitral stenosis are those of an inflammatory process involving the endocardial covering and the underlying connective tissues which constitute the framework of the valve. The primary event is an inflammatory reaction of a proliferative type, with a focal lesion, the submiliary nodule, a characteristic feature of a rheumatic infection. These areas of inflammation spread to the endocardium and are associated with fibrinous deposits which form small vegetations on the surface of the valve. The vegetations are found on the margins of the cusps, in linear arrangement, and may spread along the chordae tendineae. The valve segment is thickened, particularly along its free margin; the endocardial folds undergo a similar reaction. It is this thickening of the two cusps, the endocardial folds, and the chordae tendineae, which is responsible for the constriction of the auriculo-ventricular orifice.

Vegetations

Mitral valve

The mitral valve is damaged in all cases of rheumatic carditis which come to necropsy; mitral stenosis is essentially an infective process of

rheumatic origin. In the early stages there is not much deformity of the valve; the changes are not sufficient to give rise to characteristic physical signs of mitral disease. As the disease progresses, all degrees of narrowing of the auriculo-ventricular channel may be observed. When mitral regurgitation as a predominant functional defect becomes a preponderant stenosis in the later phases of the malady, the post-rheumatic fibrosis may be succeeded by a rigid bone-like structure from calcification of a part or the whole of the valve cusp with a button-hole, fish-mouth, or funnel-shaped opening (see p. 293).

Occasionally mitral stenosis develops in the course of subacute bacterial endocarditis from obstruction of the mitral orifice by the large ulcerated vegetations which characterize this infection. Mitral stenosis due to atherosclerosis with calcification of the cusps is sometimes seen in senile hearts. Regurgitation without stenosis may develop from endocarditis in the early stages of inflammation, but this functional defect is difficult to determine at necropsy. There is pathological evidence to support the view that it can occur in the later stages of the disease from sclerosed and shortened chordae tendineae, a rheumatic inflammatory process with dilatation of the auriculo-ventricular ring in consequence of great enlargement of the left ventricle.

*Other causes
of mitral
stenosis*

A heart-muscle poisoned by rheumatism and the additional work required of the heart as a result of the valvular defect are recognized causes of dilatation and hypertrophy of one or more of its chambers. The increased load from mitral stenosis is chiefly carried by the left auricle and the right ventricle, and it is in these chambers more than the others that the greatest degree of enlargement may be expected. There may, however, be an equal distribution of hypertrophy in both ventricles, and dilatation may be conspicuous in either or both of the auricles. The heart-muscle does not always show the characteristic signs of a rheumatic inflammatory reaction unless heart failure has developed during the acute or subacute stages of the infection. Apart from hypertrophy the myocardium may be histologically normal. The heart in these cases is hypertrophied and dilated as a result of the increased work imposed upon it by the valvular lesion, and failure may develop from an exhausted heart-muscle presenting no gross signs of a diseased myocardium: other unknown factors are also responsible for enlargement and myocardial failure.

*Dilatation and
hypertrophy*

There are no symptoms distinctive of mitral stenosis. When subjective sensations are complained of, they cannot be assessed in terms of the valve defect if the equilibrium of the circulation is disturbed by complications which arise during the development of the lesion. Although mechanical obstruction of the mitral orifice increases the work of the heart, the reserve force and accommodation capacity of the heart are sufficient to prevent any reduction in the normal output of blood from the ventricles during each cardiac cycle. Without an effective compensatory mechanism mitral stenosis would be expected to result in a lowering of the pressure in the left ventricle, an increase of pressure

*Compensatory
mechanism*

in the pulmonary circuit, a fall of arterial pressure with slowing of the circulation rate, and a disturbance in the exchange of gases in the blood. A compensatory rise of pressure in the left auricle, and slowing of the diastolic filling time in the left ventricle, with an increase in the suction action of this chamber, are factors which increase the rate of flow through the constricted mitral orifice and maintain an adequate output of blood from the ventricle with each beat.

Origin of murmurs

This speeding up of the velocity of flow through the mitral orifice gives rise to eddies in the blood-stream and vibrations of the valve cusps, which are recognized as murmurs; but, so long as the ventricular output is not diminished, the additional work of propelling the blood through the narrowed mitral orifice does not necessarily cause symptoms. The auricle may dilate and hypertrophy, the rise of pressure felt in this cavity may lead to an increase of pressure in the pulmonary circulation and the right side of the heart, and yet symptoms of myocardial disturbance may not be manifest. The extra load carried by these different chambers, but chiefly by the left auricle and right ventricle, is responsible for symptoms or signs of circulatory failure in the later phases of the disease.

(2)—Clinical Picture

(a) Symptoms

Breathlessness

Breathlessness is common in patients with mitral stenosis and has a direct relation to effort. It is an early symptom in some, and a conspicuously late manifestation of disease in others. In the beginning unusual breathlessness is complained of after effort which hitherto could be performed without any respiratory discomfort. Gradually physical activities have to be abandoned, and the patient is breathless on slight exertion or at rest. When breathlessness occurs at rest, and there is no other cause to explain it, it is safe in most instances to interpret it as a symptom of congestive failure. The degree of breathlessness will depend upon the depth of venous congestion; rapid and regular breathing is observed in some, paroxysmal in others, with alternate shallow and deep breathing and attacks of asthma (cardiac asthma) more often at night, a conspicuous feature of the respiratory distress. The patient is obliged to sit propped up in bed, or in a chair (orthopnoea).

Cardiac asthma

Other symptoms of congestive failure

Dyspnoea of this type is associated with other, less distressing symptoms of congestive failure. Fatigue, with a sensation of complete exhaustion, precordial pain, an upper abdominal ache from an enlarged liver, a persistent cough with bronchial expectoration, haemoptysis from pulmonary infarction, and sleeplessness are cardinal symptoms of congestion in these cardiac invalids.

Palpitation is common in auricular fibrillation, which is one of the most important causes of the congestive failure syndrome. Nausea and vomiting are often closely related to systemic venous congestion.

Embolic phenomena

Embolic phenomena are responsible for certain symptoms which depend upon the site of the embolus; the chest pain of a pulmonary

embolism and the pain of splenic infarction or of embolic obstruction in a systemic vessel are events in the course of this malady.

Some symptoms can be attributed to causes other than failure of the heart to maintain the circulation. In children particularly, but also in adults, symptoms of toxic debility from active rheumatism or some other intercurrent infection may be associated with obvious signs of disease; they are a manifestation of a toxic state and not of mitral stenosis or heart failure.

*Symptoms of
toxaemia*

(b) Signs

The signs of mitral stenosis are well defined and can be accepted as unequivocal evidence of valvular disease. The essential diagnostic sign is a murmur best heard over the mitral area, occurring during the diastolic phase of the cardiac cycle, low pitched and of a crescendo quality when it fills all of diastole, ending with an abrupt and loud first sound, and with accentuation of the pulmonary second sound; when it does not occupy the whole of diastole, but is heard only in early and mid-diastole, the crescendo is replaced by a diminuendo effect. It is usually rumbling and coarse, but may be soft with a higher tone not unlike the diastolic murmur of aortic regurgitation. The loud first sound is almost an essential feature, but the accentuated or reduplicated pulmonary second sound so often observed is not always present. The murmur is best heard at the apex, or where the apical impulse is located. It is sometimes heard over a wide area, and occasionally is audible well inside the cardiac impulse extending up to the pulmonary area, but is usually localized within a small area. The rule is to hear a systolic murmur as an associated sign which may be short or long, and loud enough to make the diastolic murmur difficult to hear.

Murmurs

It is not always possible to place these murmurs in their respective places in the cardiac cycle, and in this way to establish their relation to the first and second sounds, particularly when the heart is beating rapidly. A safer and easy way of defining the constituent elements of these murmurs is to time them from the quality of the auditory vibrations which the ear receives. The chief differences, which serve as a useful guide in the interpretation of the mitral murmurs, are the low pitch, rumbling character, and abrupt ending of the diastolic murmur, and the higher pitch and often harsher tone of the murmur in systole.

*Differentiation of
systolic and
diastolic
murmurs*

The diastolic murmur is caused by the increased velocity of the flow of blood through the narrow mitral orifice at the time in the cardiac cycle when the auricle is completely filled and the ventricle empty. The valve opens at this time and the difference in pressure in these chambers is at its greatest. The velocity of the blood-flow is rapid, and the vibrations set up by eddies formed in the blood-stream become audible as murmurs. It is therefore in early diastole that the murmur of mitral stenosis first appears. In presystole, when the auricle is contracting, pressure in this chamber is at its highest and a larger amount

*Cause of
diastolic
murmur*

*Presystolic
murmur*

of blood is forced into the ventricle, the rate of flow is increased, and the vibrations of the valve cusps and their supporting structures are audible as a presystolic murmur. The diastolic phase of the cardiac cycle shortens as the heart-rate is increased, and in these circumstances a full diastolic murmur filling the whole of diastole is heard. When the rate is slow, diastole is lengthened and early diastolic and presystolic murmurs may be recognized separately with a gap between them.

*Variations
in diastolic
and
presystolic
murmurs*

Since the murmur depends upon the velocity of the blood-flow through the narrowed auriculo-ventricular orifice, the greater the degree of stenosis, the more rapid will be the blood-flow and the more easily heard the murmur, and the more likely will it be to occupy the whole of diastole. The character of the murmur is affected by the rate of the flow and the degree of narrowing of the mitral valve. When the heart-rate is slow, diastole is long and the murmur is heard best in presystole and may only be heard in this phase of diastole; with moderate increase in rate the murmur is audible in early and late diastole, and in the more rapidly beating heart it occupies the whole of diastole. Similar variations occur in slight, moderate, and considerable degrees of stenosis.

*Effect of
auricular
fibrillation*

Since the velocity of blood-flow from the auricle to the ventricle depends on the difference of pressure in the two chambers, and the pressure changes are greatest when the auricle contracts, the character of the murmur is altered by the failure of the auricle to contract in auricular fibrillation. In this disorder of rhythm the auricles are virtually paralysed, and the ventricle fills more rapidly in early diastole than presystole. This irregularity is responsible for one of the chief variations of the murmur of mitral stenosis. The presystolic element in the diastolic murmur may be lost, and the murmur be only audible in early and mid-diastole. When the auricles are fibrillating the heart-rate is rapid, diastole is short, and the murmur fills it; in these circumstances the crescendo murmur of presystole is maintained. When the heart-rate is slow in auricular fibrillation, as in treated cases, or when there is naturally slow action of the ventricles with long diastolic periods, the murmur is lost in presystole and has no longer a crescendo character; or the presystolic murmur may be audible in the short cycles and be absent in the long ones. The murmur may not be audible in any part of diastole in cases with auricular fibrillation, but may appear when a normal rhythm is restored as an early diastolic murmur; it may lose its coarse character and become difficult to distinguish from the murmur of aortic regurgitation.

Heart block

In partial heart block with lengthening of the auriculo-ventricular conduction and a normal rhythm a mid-diastolic murmur is heard; this murmur is sometimes audible in children without any valvular defect.

*Examination
of patient*

The characteristic murmur of mitral stenosis is best defined in early cases, when the narrowing is slight, by examining the patient in a recumbent position lying on the left side after an exercise test. The heart-rate is raised by this procedure, and the velocity of blood-flow

through the constricted mitral orifice is rapid and the murmur audible. If under these conditions a diastolic murmur is not heard, the diagnosis of mitral stenosis should not be made. The administration of amyl nitrite quickens the heart-rate and serves the same purpose as an exercise test.

A thrill palpable at the apex and felt in diastole commonly accompanies the murmur. It must not be confused with the pseudo-thrill of an overacting heart. It is produced in the same way as the murmur, and when felt has the same significance provided that it is well defined and distinctly felt. *Apical thrill*

In cases of free aortic regurgitation, with much enlargement of the heart, of syphilitic origin, a murmur which has the timing and quality of the murmur of mitral stenosis is sometimes audible in the region of the apex. This is the well known but little understood Austin Flint's murmur (see p. 351). Syphilis rarely if ever damages the mitral valve, and there is no post-mortem evidence of mitral stenosis in these cases. When rheumatism is the cause of aortic regurgitation, it is not safe to diagnose a Flint's murmur on these signs, for it is probable that the mitral valve is always damaged in these circumstances. *Flint's murmur*

A diastolic murmur resembling the murmur of mitral stenosis is occasionally observed in patients with pernicious anaemia. A murmur of similar timing and character is heard in young subjects with heart failure from carditis, without any evidence at necropsy of mitral disease. It may be that this murmur is produced by relative narrowing of the auriculo-ventricular orifice from dilatation of the left ventricle. *Other causes of diastolic murmur*

All degrees of cardiac enlargement are observed in mitral stenosis; not infrequently there is no increase in size of the different chambers during a long period of development of the disease. Predominant hypertrophy of the ventricles or relative dilatation of the auricles cannot be recognized clinically with any exactness. Epigastric pulsation is an unreliable diagnostic sign of an enlarged right ventricle; and displacement of the heart to the left is uncertain evidence of left hypertrophy. Usually the right ventricle is much more hypertrophied than the left, and increase in size of the left auricle is the rule. But in many cases, and more especially in the later stages of the disease, the whole heart is enlarged; the clinical signs of enlargement are not distinctive of mitral stenosis. *Cardiac enlargement*

(3)—Diagnosis

A radioscopic examination is an accepted method of diagnosing mitral stenosis, for all the chambers of the heart can be seen and their shape and size accurately measured. In the antero-posterior view the enlarged right ventricle forms a convex border between the pulmonary artery above, which may be dilated, and the left ventricle below, which may or may not be enlarged. The right auricle appears on the right border with the ascending aorta and superior vena cava above. Exceptionally the left auricle is conspicuously dilated and forms part of the right *Radiology*

border between the right auricle and ascending aorta. The enlarged

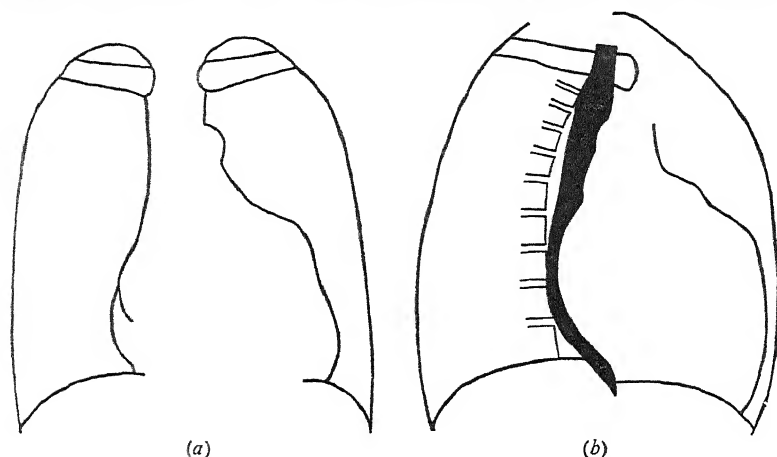


FIG. 40.—(a) Female aged 28. Mitral stenosis. Tracing of teleradiograph, showing enlargement of conus, pulmonary artery, and left auricle. (b) Same case, right oblique position, oesophagus outlined with barium, showing enlargement of left auricle and conus

left auricle can be seen posteriorly in the right oblique position; it displaces the oesophagus and can be outlined by giving the patient a barium meal. These changes in the shape and size of the heart shadows are shown in Figs. 40 and 41.

*Signs of
auricular
fibrillation*

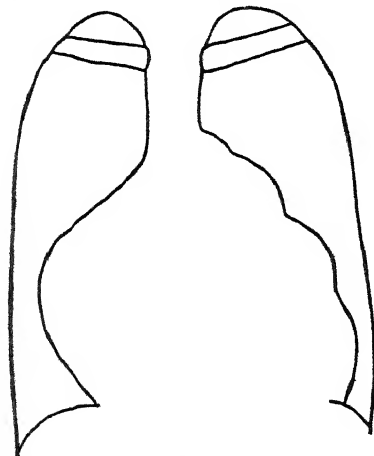


FIG. 41.—Female aged 45. Mitral stenosis and auricular fibrillation. Tracing of teleradiograph, showing aneurysmal dilatation of the left auricle, with enlargement of the conus and pulmonary artery

infarction in the pulmonary circuit with haemoptysis and pleural effusion, may be presenting signs in some cases; in others hepatic engorgement

Auricular fibrillation is a common complication of mitral stenosis, and a chief cause of congestive heart failure, increase in size of the heart, and changes in the character of the heart sounds and the associated murmurs. The relation between this disorder of rhythm and valvular disease of this type is so close that it is justifiable to take the view that, when auricular fibrillation develops as an established rhythm in subjects under the age of forty years, it is usually due to constriction of the mitral orifice. The consequences are serious, as revealed by the gross changes in the physical signs. Pulmonary congestion and deep cyanosis, or

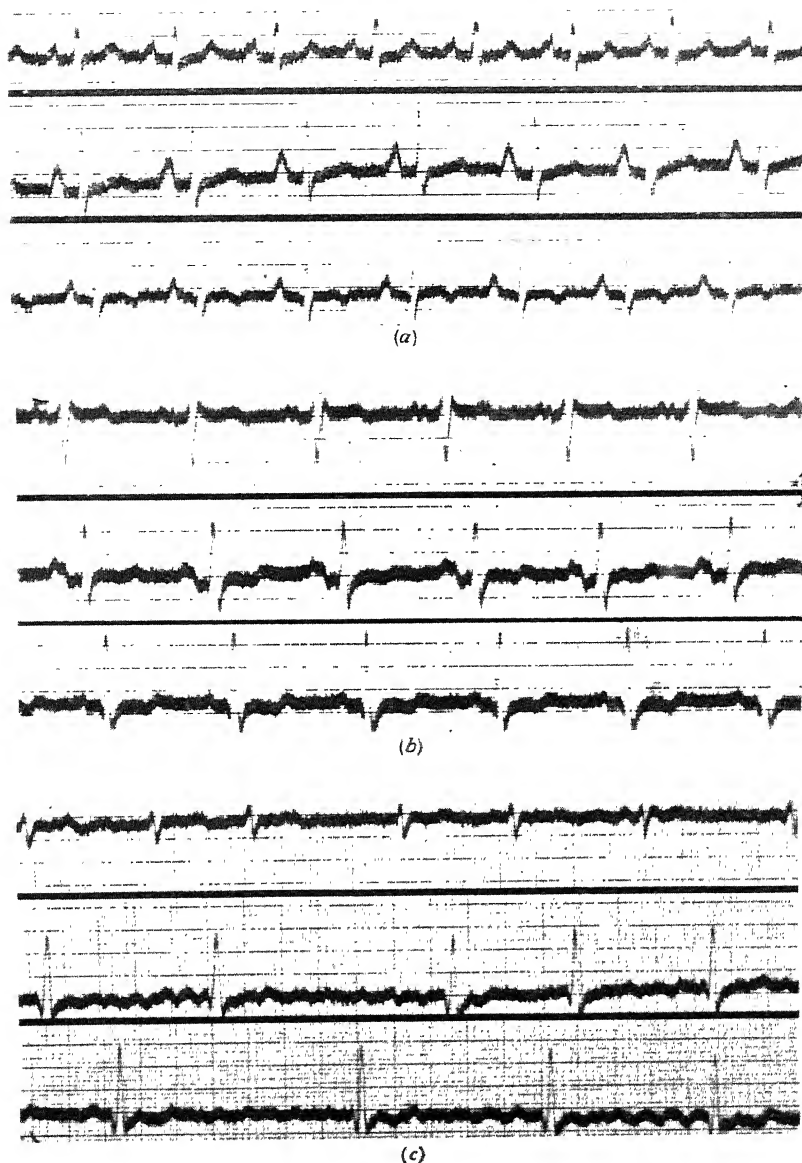


FIG. 42.—(a) Electrocardiogram showing unusually high P-waves with bifurcation, with no right-sided preponderance. (b) Electrocardiogram showing plateau-shaped and bifurcated P-waves with right-sided preponderance. (c) Electrocardiogram showing auricular fibrillation and right-sided preponderance

from chronic venous stasis may make ascites a conspicuous feature. Embolic phenomena not infrequently arise from mural thrombi formed in the auricular appendages; these thrombi become detached and are carried in the blood-stream to lodge in some part of the arterial tree, with signs depending on the site and size of the occluded vessel. Paralysis of the recurrent laryngeal nerve from pressure of the pulmonary artery, displaced upwards by the enlarged left auricle, is sometimes observed when there is great enlargement of the heart. Subacute bacterial endocarditis is a rare complication of mitral stenosis.

*Electro-
cardiography*

The electrocardiogram may give confirmatory evidence of mitral stenosis. The characteristic changes in the curve are a high bifid plateau-shaped P or auricular wave, and a deep S in lead I with high R in lead III. These are signs of increased auricular activity with enlargement of the auricle, and right axis deviation and preponderating hypertrophy of the right ventricle. Changes in auriculo-ventricular and intra-ventricular conduction, and all types of irregular heart action, occur in mitral disease and can be accurately diagnosed by electrocardiography. Electrocardiograms of three patients with mitral stenosis are shown to illustrate some of these abnormalities (see Fig. 42).

3.—MITRAL REGURGITATION

(1)—Morbid Anatomy

649.] The mitral lesion which is the cause of regurgitation is an inflammatory reaction of the valve to an active rheumatic infection. In the initial phases of the infection the valvular deformity is slight: the closure of the mitral orifice is incomplete, due to marginal thickening of the cusps, and regurgitation takes place during ventricular systole. As the disease progresses there is a spread of this inflammatory process to other parts of the valvular structure, and the thickened rigid cusps obstruct the mitral orifice and present a characteristic pathological picture which has been described in the section on the morbid anatomy of mitral stenosis (see p. 310). In rare cases there may be a considerable degree of regurgitation without stenosis. This occurs when the chordae tendineae, retracted by the inflammatory process, prevent the closure of the valve cusps without causing any obstruction. Another exceptional cause of regurgitation is the detachment of the valve cusps from the papillary muscles by rupture of the chordae tendineae in the course of an acute and virulent infection.

(2)—Diagnosis

*Interpretation
of apical
systolic
murmur*

The diagnosis of mitral regurgitation depends upon the recognition and correct interpretation of an apical systolic murmur. To pause before correlating this murmur with mitral disease is justifiable for several reasons: the physical factors which produce it cannot be defined in a precise manner, there is no background of pathological evidence

that can be relied upon, nor can its mode of production be described with anatomical accuracy. This murmur is so frequent and occurs in so many conditions, that it is not surprising that there should be much confusion in assessing its significance. A systolic murmur is commonly heard in the region of the apex, and is almost the rule when the heart is beating rapidly after strenuous exercise or from excitement, and in the overacting heart of thyrotoxicosis. The heart sounds are accentuated, and the murmur, being often loud, transmitted over a wide area, and accompanied by a diffuse cardiac impulse, is apt to convey the impression that the heart is enlarged.

It has been proved by radiological examination that there is no increase in size of the heart. In these circumstances the murmur cannot be regarded as caused by stretching of the auriculo-ventricular ring from dilatation of the ventricle. Its occurrence with a rapid ventricular rate may be due to incompetence of the valve, and can be interpreted as a functional defect and a physiological condition. A murmur transmitted to the apex from the pulmonary area is less confusing and easily recognized, for it is not loud and has the quality and character of the pulmonary murmur.

An exocardial murmur arising outside the heart may closely resemble one of endocardial origin, and present some difficulties in diagnosis. Friction sounds from old or recent pericarditis or a roughened pleura are sometimes audible as a blowing or short superficial murmur systolic in time and heard over a small area at the apex. Characteristic to-and-fro friction sounds are easily recognized; occasionally the diastolic element is wrongly interpreted as an endocardial sign.

*Exocardial
murmur*

Cardio-respiratory murmurs are often incorrectly diagnosed as a sign of mitral disease. They are breath sounds interrupted by the movements of an overacting heart and can be distinguished by their respiratory relationship. They are best heard on deep breathing and may disappear when the breath is held; they sometimes have a wide distribution but are generally heard over a small area in the region of the heart.

*Cardio-
respiratory
murmurs*

Some systolic murmurs which are loud in one position and inaudible in others, unrelated to breathing, and of varying intensity and character, can be considered normal in some people. A murmur which can be attributed to valvular disease is heard over the cardiac impulse, and differs in character from a basal murmur with which it may be associated. It occupies the whole of systole, is conducted outwards, and is accompanied by a systolic thrill which is palpable in the region of the apex. In some cases the diastolic murmur of mitral stenosis is masked by the loudness and length of the systolic murmur. It is usual to regard such a murmur as a sign of mitral regurgitation and valvular disease. Such a murmur without a thrill may be due to mitral regurgitation from dilatation of the auriculo-ventricular ring when the heart is much enlarged; it is often present in heart failure and is usually interpreted as a sign of relative mitral insufficiency. A murmur which can be regarded as a certain sign of regurgitation from mitral disease is the

*Other types
of murmurs*

systolic murmur of mitral stenosis, accompanying the diastolic murmur. It has frequently a low-pitched soft quality and in other circumstances would not be considered a sign of a valve defect. The fact that it may be absent in mitral stenosis is further proof that more evidence is required in the diagnosis of mitral regurgitation than the character and timing of the apical systolic murmur. When this murmur develops in the course of a rheumatic infection and is associated with cardiac enlargement or other signs of structural disease, it is usually possible to tell its origin and significance. Fig. 43 is a tracing of a teleroadiograph

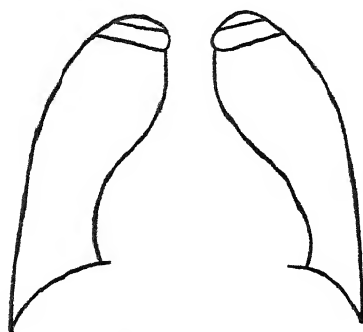


FIG. 43.—Male, aged 8. Acute rheumatism and mitral incompetence due to ruptured mitral cusp (necropsy finding)

of a child with mitral regurgitation and cardiac enlargement without stenosis, in whom the diagnosis was confirmed at necropsy.

(3)—Significance of Mitral Regurgitation

The importance attached to mitral regurgitation, in relation to the heart in its capacity to meet the demands required for maintaining the circulation adequately, must logically depend upon the degree of the valve defect and whether it is functional or structural in origin. If symptoms can be attributed to mitral regurgitation they must be due to a considerable reduction in the cardiac large reserve force. With each ventricular systole more blood is discharged into the auricle and more work is required of this chamber in expelling its contents. The ventricle receives, in addition to its normal amount, the blood which has regurgitated into the auricle, and in consequence has an added burden imposed upon it. It is not possible to determine from the character of the murmur the degree of incompetence of the valve, nor can it be measured accurately after death. Symptoms in the patient with a regurgitant murmur must be attributed to causes other than the physical factors of an incompetent valve. Healthy heart-muscle with such a heavy burden imposed upon it, as is known to exist in certain forms of congenital valvular disease, may not show any impairment of its reserves over a period of many years. In a patient with mitral regurgitation and symptoms due to reduced reserves the valvular defect is not an isolated event but is part of a disease which has produced inflammatory and degenerative changes in the heart-muscle. The incompetent valve may be regarded as the least important factor responsible for heart failure.

*Importance
of associated
lesions*

When a damaged mitral valve is the cause of regurgitation, there is usually some degree of stenosis with regurgitation or obstruction as the chief defect. To assess their relative values in terms of symptoms it is

necessary to estimate the effect of the lesion on the reserves of the heart. When the cardiac reserves are reduced sufficiently to cause heart failure, the symptoms are the same whether regurgitation or obstruction is the predominant defect. The mechanical burden imposed upon the myocardium by regurgitation does not increase the work of the heart sufficiently to produce symptoms from impairment of its reserve force. When symptoms arise they must be attributed to a damaged myocardium and not to incompetence or stenosis of the valve.

In developed mitral stenosis certain complications may supervene in the course of the disease and cause symptoms which are commonly associated with narrowing of the auriculo-ventricular channel, particularly heart failure from auricular fibrillation, embolic phenomena, and bacterial endocarditis. Whatever may be the factors responsible for auricular fibrillation, there are no pathological grounds for attributing this disturbance of rhythm to leakage of the valve except in its association with mitral stenosis; neither is there evidence for claiming that embolic symptoms may develop as a direct effect of regurgitation. Subacute bacterial endocarditis may develop in cases with a structural valvular defect.

*Relation of
auricular
fibrillation
and embolic
phenomena to
regurgitation*

The only sign of mitral regurgitation is an apical systolic murmur, and it is not easily differentiated from systolic murmurs due to other causes. It has not the diagnostic value of the diastolic murmur of mitral stenosis or of aortic regurgitation; it is in fact an inaccurate sign of mitral disease. It is impossible to be certain from the quality and character of the murmur whether it is produced by a functional or a structural defect of the valve. It is usual to define it as of structural origin when it is harsh and loud and there is a past history of rheumatism. When functional, it is less likely to be loud and is associated with an overacting or failing heart. When used as a guide the apical systolic murmur serves a useful purpose in the recognition of mitral disease and structural damage in other parts of the heart.

*Structural
and functional
murmurs*

4.—PROGNOSIS

650.] The course of events in mitral disease and the duration of its different phases can be determined by correlating the origin of stenosis or regurgitation with the associated anatomical changes and functional disorder which the heart displays. Signs of venous congestion, the degree of cardiac enlargement, the presence of auricular fibrillation, and the response to effort are signs which can be relied upon in forecasting the course of the disease. Signs of systemic venous congestion appear late and indicate that the disease has nearly run its course. When the heart is enlarged and dyspnoea on slight exertion is a chief complaint, the cardiac reserves are much reduced, the heart is no longer able to maintain the circulation adequately, and congestive signs, if not present, are likely to develop in a short time. Auricular fibrillation, when

*Venous
congestion*

*Auricular
fibrillation*

established, hastens the onset of heart failure and is a serious complication. It usually develops in the course of the disease, with the incidence highest in the third and fourth decades, and is rarely observed in children; it is a common cause of heart failure and therefore a most important prognostic sign. The prognosis is more favourable in cases without cardiac enlargement. When symptoms are due to a high ventricular rate which can be controlled by treatment, the outlook is better than in cases with failure and a slow heart-rate. Recurring

*Cardiac
enlargement
and heart-
rate**Infections and
toxaemia*

rheumatic infections lead to progressive inflammatory changes in the heart-muscle with greater deformity of the valves, and therefore favour the development of cardiac failure; a chronic toxic state from any source may also poison the myocardium and lead to a circulatory breakdown. In a small proportion of cases the prognosis is that of bacterial endocarditis, always ending fatally, usually within six months of the onset of the symptoms. It is of some value in prognosis to know the age of the patient at the time of the initial infection, for the longer the duration of the disease the greater is the likelihood of the occurrence of auricular fibrillation and heart failure.

*Duration of
disease**Type of
disease as
basis of
prognosis*

There is general agreement that it is not safe to rely upon the type of valvular disease as a basis of prognosis, for there are too many other factors concerned in the cardiac breakdown. To conclude that the patient with a regurgitant murmur has a better expectation of life than one with stenosis it is necessary to have full information about the response to effort, the size of the heart, the rhythm, infections, or a toxic state. With these requirements satisfied there is a sound basis for prognosis without relying upon the character of the murmur and the degree of valvular deformity. It is probably true that structural disease of the heart as a whole is more commonly associated with stenosis than with regurgitation, and in this respect valvular disease can, within a restricted field, be used as a prognostic sign.

Age

In the young patient with stenosis the active phases of rheumatism are longer and the quiescent intervals are shorter than in the child with a regurgitant murmur. There is a tendency for the rheumatism to be less active in adolescents and adults, and the condition of the patient left with residual damage may remain stationary for many years. Mitral disease is sometimes observed in the fifth decade, the result of an infection in childhood.

*General
conditions
of life*

When the child or adult is protected from the stress and strain of everyday life, and has suitable occupation, proper nourishment, and adequate treatment for intercurrent infections, the heart mischief may not progress and the functional efficiency may remain unimpaired. The child of well-to-do parents has a better outlook than one living in the unhealthy home surroundings of the poorer classes. The artisan and the labourer for similar reasons are less able to combat the ravages of the disease than are the sedentary worker and the professional man.

Pregnancy

Frequent pregnancies tend to undermine the general health and

shorten the life of the woman with mitral disease, although one or two pregnancies do not seem to aggravate the condition when signs of congestion are absent, the heart is not much enlarged, and the rhythm is normal.

5.—TREATMENT

651.] The simple rules relating to cause and effect apply in the management and treatment of patients with mitral disease. The cause is rheumatism, and the effect is a damaged myocardium and a valvular defect. The object of treatment should be to arrest the development of heart disease and to prevent the onset of heart failure. The initial rheumatic infection in the majority of cases is in childhood and adolescence, and it is at this time that an attempt should be made to control those factors which influence the incidence and course of rheumatism and its cardiac manifestations. The management of carditis in its different phases is dealt with elsewhere (see p. 250). *Preventive*

With regard to valvular disease and its associated myocardial damage in the adult as a residual effect of rheumatism, the treatment is that of a chronic malady and the complications. In the patient with valvular disease but without symptoms referable to the heart, the lesion is inactive and no special treatment is required. Cardiac subjects belonging to this class can lead normal lives but should be warned of the consequences of ill-health, infections, unhealthy habits, and excesses in work and play. With moderation in their daily activities as the keyword, no special restrictions need be imposed.

Two conditions favour the development of heart failure: (i) Infection activates a quiescent lesion and sets up an inflammatory process in the heart-muscle and valves which gives rise to the characteristic symptoms of a toxic state, of a failing heart, or in a small proportion of cases of bacterial endocarditis. (ii) The mechanical effect of the valvular lesion is to obstruct the flow of blood through the heart, and the increased work is a factor contributing to heart failure. Physical exercise and manual work also increase the work performed and cause symptoms of failure in a heart with diminished reserves. *Infection*
Prevention of mechanical strain

The valvular defect cannot be altered, but the burden imposed upon the heart by exercise and work can be lessened by restricting the activities of the patient. Infection can be more or less controlled by suitable treatment. Breathlessness on effort is the most important evidence that can be obtained of the functional efficiency of the heart, and the ease with which it is produced is an accurate measure of the degree of heart failure. The amount of exercise required to produce this symptom indicates the amount of exercise, games, or work that should be allowed. The patient's physical activities should be restricted within the limits of his exercise tolerance. Games and manual work may be permitted, provided that there is no complaint of breathlessness. As the disease progresses breathlessness is experienced with less exertion,

until at a later stage it is a conspicuous symptom at rest and is associated with signs of congestion.

Aim of treatment

The objective in the treatment of congestive failure is to restore the functional efficiency of the myocardium, so that the ventricles are completely emptied with each contraction. If signs of venous stasis are present, with full pulsating veins in the neck, an engorged liver, and pulmonary congestion, there will be residual blood in the ventricles when they have finished their contraction. When these signs are absent, the ventricles are able to deal with the blood supplied to them. A diseased heart dilates to meet the increased demands made upon it; dilatation is a sign of exhaustion and an index of approaching heart failure. It is difficult clinically to distinguish dilatation from hypertrophy, and for this reason reliance cannot be placed on enlargement of the heart as an accurate measure of the degree of heart failure which is present. The signs to be depended upon are in the venous and not in the arterial system, and the chief aim must be to determine the presence or absence of increased venous pressure in the veins. When these signs are present, the minimum amount of work must be imposed upon the heart.

Restriction of physical effort

Since physical effort increases the activity of the heart, and less work will be required of this organ with the body at rest, every unnecessary movement should be avoided. Recovery will be hastened if the patient is fed and if he is lifted when any movement has to be made. The position of the patient is important; a sitting posture with the body upright in a chair and the legs hanging down, with the feet supported, by lowering the pressure in the superior and inferior venae cavae, diminishes the inflow of blood to the right auricle and relieves the heart of an extra load which it cannot carry. The venous pressure is raised in the lower extremities, and as a result the retained fluids collect in the subcutaneous tissues in these regions. Special chairs are constructed which serve as a bed, and for the wards of a hospital the modified Lawson Tait bed, which Lewis devised, serves the same purpose. Many patients are content to remain in the chair during night and day. When an ordinary chair is used, they lie a few hours in bed to relieve the body-muscles by a change of position.

Withdrawal of excess fluid

The large amount of fluid which accumulates in the legs from the effect of gravity can be drained by inserting Southey's tubes or making superficial skin incisions; by this procedure the blood volume is not increased from the reabsorption of the retained fluids and less work is required of the heart. Venesection is a more rapid method of obtaining the same result and is always indicated when the venous pressure is unusually high; 10 to 20 ounces should be withdrawn. The improvement in the circulation from bleeding is due to the reduction in the blood volume and a lowering of the viscosity of the blood from its dilution by the reabsorption of lymph. A resting period of two months is usually required to restore the circulatory equilibrium.

Digitalis

The principal effect of digitalis is to slow the ventricular rate, which in

auricular fibrillation is usually rapid. It is generally admitted that digitalis also increases the cardiac output by its direct action on the heart-muscle, and for this reason it is prescribed in the treatment of heart failure with a normal rhythm and rapid pulse-rate. All are agreed that the spectacular effect of digitalis is best seen in auricular fibrillation with rapid ventricular rate. Digitalis should be given by the mouth and is only effective if administered in large enough doses to obtain a sufficiently high concentration in the tissues. Small doses are adequate after this concentration has been reached and can be continued without fear of toxic symptoms from their cumulative action.

*Mode of
administration*

A useful procedure is to give 60 minims of the tincture every day for a week, and then to reduce the dose to half. If the powdered leaf is used, 14 grains are the equivalent of 15 minims of the tincture: 2 to 3 grains are an average maintenance dose. Some prefer a more rapid concentration in the tissues by giving a large initial dose calculated from the body-weight: 15 minims of the tincture per stone followed by an equal amount in 30-minim doses every six hours. This method is not often employed in general practice, as the patient must be weighed and kept under close observation for several days. Unstandardized tinctures of digitalis should never be used, and the strength of the tincture should be known. Nausea and vomiting may be avoided by giving the freely diluted tincture in a single daily dose, or twice that amount on alternate days. There are no indications for giving digitalis by intramuscular injection; absorption is slow, and consequently there is too low a concentration of the drug in the tissues to affect the action of the heart.

Dose

*Prevention of
nausea and
vomiting*

Strophanthin, a mixture of glycosides present in *Strophanthus kombé*, and ouabain, the glycoside present in *Strophanthus gratus*, act on the heart in the same way as digitalis. They are given by intravenous injection as an emergency measure and can be repeated in six hours if there is not adequate slowing of the heart-rate; a third dose is sometimes required after a further interval of twelve hours. The dose for intravenous use is $\frac{1}{2}$ grain of either strophanthin or ouabain in 4 c.c. of physiological saline. Tincture of strophanthus is sometimes given to patients who are unable, from gastric intolerance, to take digitalis. It is less reliable than digitalis in controlling the ventricular rate and may cause diarrhoea and disturbance of vision. The dose is 20 to 30 minims daily for a week, followed by a maintenance dose of 10 to 15 minims daily; the prescribed amount should be given in three or four divided doses. When digitalis has failed, strophanthus rarely succeeds in slowing the heart-rate adequately or in relieving congestion, and consequently is not often prescribed.

*Strophanthin
and ouabain*

Within the last few years digoxin, a pure glucoside of *Digitalis lanata*, has taken the place of strophanthin in the treatment of heart failure with auricular fibrillation and a high ventricular rate when a rapid effect is required. It can be given by intravenous injection or orally, and a rapid reaction is obtained by both these procedures. The intravenous method is definitely indicated and may be reserved for patients with nausea and

Digoxin

vomiting who are unable to take food or drugs by the mouth. The dose is 0.75 to 1.0 mgm. dissolved in a small quantity of sterile physiological saline and injected slowly into a vein of the forearm. A second injection of 0.5 mgm. should be given in six hours and repeated as a daily maintenance dose until the ventricular rate has fallen to 80. A slowing of the rate below this level and bigeminy indicate that the injections should be discontinued for a few days. The initial dose for oral administration is 1 to 1.5 mgm. followed by a daily maintenance dose of 0.5 to 0.75 mgm. in divided doses. An average dose is 0.25 mgm. twice daily so long as it is necessary to control the ventricular rate, and there are no signs of intoxication.

Diuretics

In a large percentage of patients the retained fluids are excreted by the kidneys, and the urinary output will be in excess of a fluid intake reduced to 30 ounces. Some, however, remain in a state of chronic venous congestion, and in them diuretics are necessary to restore the fluid balance. Theobromine and sodium salicylate (diuretin) 10 to 15 grains three times a day may be added to the digitalis mixture, or it may be given in tablets or cachets each containing $7\frac{1}{2}$ grains. One of the most effective diuretics in use at the present time is injection of mersalyl (salyrgan). It is a highly complex and non-irritating compound of mercury and should be injected intravenously in doses up to 2 c.c., diluted with 10 c.c. of physiological saline, and given every third or fourth day. Its action is rapid and completed in eight to twelve hours, and large quantities of urine up to 250 fluid ounces or more are excreted in this short time. It is more effective if ammonium chloride, in doses of 40 to 80 grains dissolved in a fairly large quantity of water, is given three times daily, throughout the course of the mersalyl injections or for two days before each injection. Mersalyl has taken the place of merbaphen (novasuro), which sometimes causes serious toxic symptoms. In cases with hydrothorax it is unnecessary to aspirate the chest, unless the amount of fluid is large and obviously causing dyspnoea and cyanosis.

Sedatives

Sedatives are always required in the treatment of heart failure and should be given in doses large enough to relieve distress and anxiety. Bromides, phenobarbitone, chloral hydrate, and, most important of all, morphine may be prescribed. There should not be any hesitation in giving morphine sulphate $\frac{1}{4}$ grain and in repeating it each night if smaller doses are not enough to make the patient comfortable.

Treatment of associated bronchitis and bronchial asthma

In heart failure with bronchitis much of the distress may be of bronchial origin; in these patients anoxaemia with cyanosis is a conspicuous feature and the chest signs are those of a generalized bronchitis. The continuous inhalation of oxygen through a nasal catheter is indicated and may bring relief when other measures fail. As it is essential to increase the air entry into the lungs, morphine, which depresses the respiratory centre and lowers the pulmonary ventilation, should be withheld or given in small doses. When heart failure is associated with bronchial asthma or with dyspnoea asthmatic and not paroxysmal in character,

ephedrine hydrochloride given in $\frac{1}{2}$ -grain doses twice or three times daily relieves the bronchial spasm and may, by dilating the coronary arteries, improve the coronary circulation and increase the cardiac output. Ephedrine hydrochloride does not increase the blood-pressure in these doses and is therefore not contra-indicated in hypertensive subjects.

It is usual to prescribe a simple diet, and in order to avoid flatulence *Diet* to give concentrated foods, and small meals without fluids. The fluid intake should be restricted to 30 to 40 ounces in the twenty-four hours.

In mitral disease with established auricular fibrillation the normal *Quinidine* rhythm can be restored by the administration of quinidine sulphate in a fairly large proportion of selected cases. This treatment is likely to be successful in about half of those cases with early mitral stenosis and not much enlargement of the heart, and when the fibrillation is of recent origin. With a history of infarction the risks of embolism are considerable when the rhythm returns to normal; these patients should not be given quinidine. Congestive failure and much enlargement of the heart are other contra-indications for the use of the drug.

It is usual to give as an initial dose 3 grains of quinidine sulphate and, *Administration and dosage* if there is no idiosyncrasy, to increase the dose until on the fifth day the amount given is 30 grains in divided doses spread over the twenty-four hours. It may be necessary to continue this dosage for a week or ten days; but, if the normal rhythm has not been restored after ten days, treatment for a longer period is not likely to be successful. Some patients revert quickly to auricular fibrillation. Complete rest and good nursing are essential features of this treatment. It is usual to give 5 to 10 grains of quinidine sulphate daily for one or two months after the normal rhythm has been restored.

The surgical treatment of mitral stenosis by cutting the valve has been *Surgery* tried but without success. It was suggested by Lauder Brunton in 1902: he made some trial experiments on diseased hearts in the post-mortem room, and on cats with healthy valves, but did not proceed further with his investigations. Valvulotomy was first performed by Cutler in *Valvulotomy* collaboration with Levine in 1923, with the object of relieving an extreme degree of obstruction with congestive failure after all medical treatment had failed to improve the condition of the patient. This patient lived for four years, but because of the failure of others to benefit from valvulotomy and of the high mortality this drastic operation has been abandoned. It is unlikely that a surgical procedure of this kind will again be attempted, for the valve defect is not the essential cause of the failure of the heart to maintain the circulation.

The surgical field has been widened to include the operation of total *Thyroid-ectomy* thyroidectomy in the treatment of mitral stenosis with heart failure. By this procedure the basal metabolic rate is lowered, a hypothyroid state produced, and the work of heart diminished. The results recorded by Blumgart, Levine, and Berlin seemed, at any rate for a time, to justify this operation, when all other therapeutic measures have failed to benefit the patient with mitral stenosis and heart failure.

*Cardio-
omentopexy*

Cardio-omentopexy employed by O'Shaughnessy in this country, and the grafting of the pectoralis major to the heart as practised by Beck and Tichy in America, in the treatment of cardiac ischaemia, are operations which have been restricted to a few selected patients with unequivocal signs of coronary sclerosis.

These surgical procedures are now on trial and, until more evidence of their value has been recorded, it is unlikely that they will be considered reasonable measures for the relief of the congestive failure of mitral disease.

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VIII.—AORTIC VALVE DISEASES

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1.—DEFINITIONS

*Incompetence
of aortic
valves*

652.] Incompetence of the aortic valves is present when changes in the valves or in the aortic ring allow the regurgitation of blood from the aorta into the left ventricle during diastole. The condition is rarely due to dilatation of the ring alone, and nearly always indicates that the valves have been deformed by pathological processes.

*Stenosis of
aortic valves*

Stenosis of the aortic valves means that, owing to pathological changes in the valves, in the supporting ring, or in both, there is narrowing of the opening and obstruction to the flow of blood from the left ventricle to the aorta during systole. Occasionally it may be due to a congenital deformity—subaortic stenosis—in which case the obstruction is due to a ring below the aortic valves. Relative stenosis is sometimes spoken of when the opening of the valves is of normal size but the aorta above is dilated; it may produce a thrill as true stenosis does, but does not lead to any of the consequences or effects of true stenosis and is only significant because it may cause difficulties in diagnosis.

*Relative
stenosis*

*Congenital
coarctation
of aorta*

In congenital coarctation (stenosis) of the aorta the narrowing is round the arch of the aorta, generally near the point where the ductus arteriosus joins the aorta and the pulmonary artery, and as some of the signs are similar to those of aortic stenosis it must be considered.

2.—AETIOLOGY

(1)—Causes

*Acute
rheumatism*

Acute rheumatism is far the commonest cause of disease of the aortic valves, whether there is aortic incompetence alone or aortic incompetence combined with stenosis. Pure aortic stenosis occurs less often than either of these two and is relatively rare in the rheumatic cases. Often when there is rheumatic aortic incompetence there is mitral stenosis as well; but, even if these are excluded, rheumatism is still the most common cause of aortic incompetence. It is true that in nearly all rheumatic cases the mitral valve has been affected and the necropsy will show some degree of old rheumatic thickening of the valve segments, but this cannot be detected at the bedside, and the clinical diagnosis of pure aortic disease does not justify the conclusion that the condition is syphilitic in origin.

Syphilis

Syphilis is the second most important cause, and the valvular lesion produced is always aortic regurgitation, aortic stenosis being never due to syphilis alone; further, when in such a case the presence of a thrill suggests the possibility of stenosis, an X-ray examination must be made to exclude dilatation of the aorta with a resultant relative stenosis. Less commonly the valvular disease is due to atheromatous changes grafted on to an old syphilitic lesion, and it is not rare for regurgitation due to syphilis (or sometimes to rheumatism) to be complicated by stenosis due to atheromatous changes.

Degenerative atheromatous change, often with calcification, is the third most common cause, but it is much less common than the other two. This is the only form which causes aortic stenosis, or at any rate a degree of stenosis sufficient to be recognized clinically as often as regurgitation, and it frequently produces pure stenosis without appreciable regurgitation.

Malignant endocarditis perhaps comes fourth, but the number of cases due to this cause depends very much on where the cases are collected: for example, it is relatively common in hospital in-patients but less common among out-patients and in general practice. Malignant endocarditis most often supervenes when there is existing rheumatic or congenital heart disease, but in the primary variety, when it attacks a heart that was previously healthy, the aortic valves are specially liable to be the seat of malignant endocarditis; congenital bicuspid aortic valves which previously have not given rise to signs or symptoms may suffer in the same way.

There is only one other group of much practical importance, the congenital cases. Coarctation of the aorta is much commoner than is generally recognized and occurs in one of each 700 necropsies at hospital (see p. 217). The slighter cases in which there is not much development of the collateral circulation may come under observation as apparent aortic stenosis—in fact there is stenosis of the aorta but not of the aortic valves, and there is not the resultant disturbance of the cerebral circulation, because one or both carotid arteries leave the aorta on the proximal side of the stenosis. True congenital stenosis of the valve is much rarer than coarctation and is generally subaortic.

Congenital bicuspid aortic valves must also be considered: these again are fairly common, being found in nearly one of each 300 hospital necropsies. About three-quarters of the cases prove fatal from other diseases, the congenital abnormality having been without effect, but in the remaining quarter the congenital bicuspid valves have been the seat of other pathological processes and the patient has died of heart disease.

Gallavardin described a type of aortic stenosis in young subjects which is not rheumatic in origin; he attributed it to subacute or chronic endocarditis of unknown cause, but it seems possible that many of his cases were really of congenital origin. Before discussing these rarer types certain statistics about the frequency of the more common varieties will be considered.

(2)—Frequency of Types

It is difficult to give accurate statistics of the relative frequency of the different types of valvular disease. Cowan and Ritchie on some extensive Scottish figures found five cases of mitral for each two of aortic disease, but this rather under-estimates the frequency with which the aortic valves are involved. The greater liability of males to suffer from diseases of the aortic valves is well shown in their figures, the numbers being almost equal for the mitral valve (1,091 to 1,064) but more than

*Degenerative
atheromatous
change*

*Malignant
endocarditis*

*Congenital
defects
Coarctation
of aorta*

*Congenital
bicuspid
aortic valves*

*Rarer types
of aortic
stenosis*

*Sources of
statistics*

*Sex and age
incidence*

five times as great in men as in women for the aortic valves (676 to 129). As regards age, 60 per cent of the aortic cases, but less than 40 per cent of the mitral cases, occurred after forty years of age.

Two recent series have been selected for discussion because they were collected from very different sources and yet show a reasonable measure of agreement in the type of valvular disease likely to be found. In Cabot's series, based on 4,000 consecutive necropsies at the Massachusetts General Hospital, about 1,500 showed some cardiovascular lesion, but of these less than 300 (18 per cent) showed any valvular disease: in Grant's series, based on 1,000 army pensioners with heart disease, 857 had valvular disease of the heart, this much higher incidence depending on the high proportion of young adults in whom valvular disease is more and pure myocardial disease is less common. In so far as these series agree they are of great value owing to the large numbers, the care with which they were studied, and the different sources from which they were collected. In Cabot's series 42 per cent of those with valvular disease had mitral disease alone, 24 per cent combined lesions, and 34 per cent aortic disease alone; the corresponding figures in Grant's series were 28, 22, and 50 per cent, the number with aortic disease being higher than in Cabot's series, and indeed higher than usual, because so many young patients with obvious mitral stenosis would have been excluded from the army. The relative incidence of the rheumatic and syphilitic cases agrees very closely, the latter forming 18 and 22 per cent of the total, which is rather surprising considering the different methods of selection.

Ætiology.

The cases with mitral stenosis alone need not be considered further, and they have been omitted from Table I. It is agreed that disease of the aortic valves is generally due to rheumatism or syphilis, but the relative importance of these two conditions is very differently estimated. In some series (Allan; Hubert) most of the cases have been considered syphilitic, whereas in others (Russell Wells) nearly all under forty have been said to be rheumatic. In a series I collected, consisting of 296 cases with disease of the aortic valves, acute rheumatism accounted for four out of each six (two-thirds), syphilis for rather more than one in six, and atheroma and all other causes for less than one in each six. A less personal view may be obtained by comparing these series of Cabot, Grant, and Campbell, and the result is shown in Table I.

Valves affected

In the largest group (more than a third of all the cases) both the mitral and aortic valves were affected. The second largest group (almost exactly one-third) contained those with pure aortic disease of rheumatic origin, the proportion with stenosis being differently estimated, because Grant's series automatically excluded the most severe cases of rheumatism in the young, in whom stenosis is most likely to follow, and Cabot's post-mortem series revealed stenosis in several cases in which it was not diagnosed clinically. The third largest group (less than a third) was of syphilitic aortic regurgitation. The general conclusion from these three series is that aortic disease may reasonably be classified

Summary.

in three groups: (1) rheumatic aortic incompetence (with or without stenosis) with mitral stenosis; (2) rheumatic aortic incompetence (with or without stenosis) without mitral stenosis; and (3) syphilitic aortic regurgitation. The first is the most frequent and the last, in my experience at any rate, a good deal the least frequent.

TABLE I.—The Aetiology of Disease of the Aortic Valves
(expressed as percentages)

PATHOGENY	NATURE OF LESIONS	CABOT	GRANT	CAMP-BELL	COM-BINED*
Rheumatism	Aortic incompetence, with or without stenosis, with mitral stenosis	41	31	41	38
Rheumatism	Aortic stenosis and incompetence	19	9	12	13
Rheumatism	Aortic incompetence alone	9	30	14	18
Syphilis	Aortic incompetence	31	30	19	27
Atheroma	Aortic stenosis and, or incompetence	..	..	7	..
Various	Aortic stenosis and, or incompetence	..	..	7	..
Total number of cases	—	155	857	296	1308

* No additional weight is given to Grant's larger numbers because the method of selection makes them less characteristic of ordinary medical practice.

(3)—Sex and Age Incidence

The age and sex incidence vary so much in the different groups that the age and to a lesser extent the sex often help in the diagnosis of the probable aetiological factor.

In the rheumatic group of my series there were equal numbers of men and women, but they were differently distributed; in those without mitral stenosis there were twice as many men as women, in those with mitral stenosis three women for every two men (see Table II). Taking these rheumatic cases as a whole, it can be said roughly that, of each six, three had aortic incompetence and mitral stenosis, the fourth had aortic stenosis as well, and the fifth and sixth were clinically without mitral disease, one having aortic incompetence alone and the other aortic stenosis and incompetence. In contrast with these figures the incidence of aortic disease was much higher in men in the other two groups. In the syphilitic group three-quarters were men and only one-quarter women, and many authorities have found an even greater male preponderance. In the atheromatous group there were seventeen men and only three women.

Rheumatic group

Syphilitic group

Atheromatous group

TABLE II.—Type of Rheumatic Valvular Disease and Sex Incidence

			MALES	FEMALES	TOTAL
Aortic incompetence and stenosis	with		9	26	35
	mitral				
Aortic incompetence	stenosis		37	52	89
Aortic stenosis and incompetence*	—		24	10	34
Aortic incompetence alone	—	—	27	15	42
Aortic and mitral valves	—	—	46	78	124
Aortic valves only	—	—	51	25	76
Total	—	—	97	103	200

* Five cases with aortic stenosis did not show any evidence of aortic incompetence while under observation.

It is easy to suggest possible reasons for a preponderance of men in the older age groups, such as a higher infection rate for syphilis, and a higher incidence of physical strain and heavy manual work making

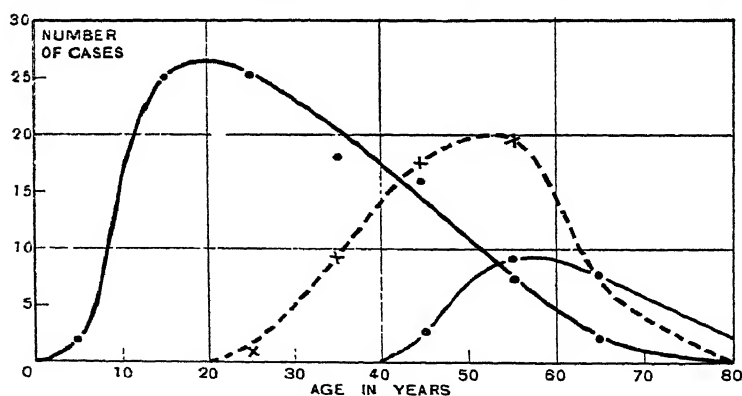


FIG. 44.—Age incidence of three main types of aortic disease. The curve to the left represents cases of rheumatic aortic disease (excluding those in whom mitral stenosis was the main feature). The middle (interrupted) curve represents syphilitic aortic disease; after 40 years of age this becomes a more common cause than rheumatic disease, which is the main aetiological factor before this. The curve to the right represents atheromatous aortic disease and shows that it is a fairly important cause between 50 and 80 years of age

the aorta more prone to disease; but it is hard to suggest any reason why the aortic valves of a boy who has not yet started serious competitive sport at school should be more liable to damage by the rheumatic infection than those of a girl.

Age incidence The age incidence is very different in the three main groups and is of

practical importance. Of those with syphilis nearly 80 per cent were between forty and sixty, without any age difference in the sexes: of the atheromatous more than 90 per cent were over fifty. On the other hand, 90 per cent of the rheumatic cases were between ten and fifty. The aetiological factors are well shown in Figure 44: nearly all those under forty were rheumatic, whereas after fifty syphilis was the responsible factor twice as often as rheumatism, atheroma occupying an intermediate position.

With rheumatic cases the incidence was more evenly spread from ten to forty-five, but there was a group of men with aortic stenosis between forty-five and fifty-five.

Figure 45 contrasts the age incidence of rheumatic aortic incompetence with rheumatic aortic stenosis and incompetence: both curves have a

In syphilitic and other cases

In rheumatic incompetence and stenosis

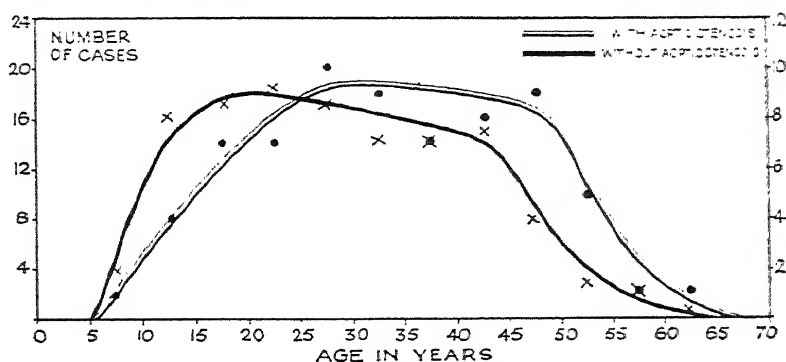


FIG. 45.—Age incidence of rheumatic aortic incompetence and stenosis contrasted with age incidence of rheumatic aortic incompetence without stenosis. When stenosis is present, the curve is displaced about five years to the right. The right-hand scale is the number of cases with aortic stenosis; the left-hand scale the number without stenosis. For this figure the presence or absence of mitral stenosis has been disregarded (*Guy's Hospital Reports*, 1933)

similar shape. It has been suggested that aortic stenosis is rare in the young and much more common in the elderly, but these curves make it quite certain that aortic stenosis does not represent a much later stage of rheumatic disease than aortic incompetence. The curve for stenosis is shifted about five years to the right, and this period may represent the usual time taken for stenosis to develop. In my experience the degree of aortic stenosis present in a rheumatic case is generally not sufficient to be of great importance in itself (i.e. by the effect it produces at the valve) but is indirectly of importance as indicating in all probability a severe attack of rheumatic carditis in the past.

3.—MORBID ANATOMY AND BACTERIOLOGY

The morbid anatomy of the various aetiological groups must be considered separately, but aortic regurgitation and stenosis may generally be considered together.

(1)—Rheumatic Group

(a) *Morbid Anatomy**Morbid
changes in
valve*

The early stages of rheumatic endocarditis can be seen post mortem in patients who die during a first attack of acute rheumatism. There is a line of small nodular swellings just within the free margin of the valve segment with some roughening and thickening and loss of transparency of the neighbouring parts of the valve. At this stage there would not be any clinical signs of developed disease of the valves, though there may be mitral regurgitation from stretching of the ring. Carey Coombs (1924) found the mitral valve affected in every case, the aortic in half, the tricuspid in one-third, and the pulmonary practically never; but often the disease of the mitral valve may be insufficient to produce signs or symptoms, and clinically the case may be one of pure aortic disease. For details of this early stage see pages 238 and 243.

*Valves
affected**Submiliary
nodules in
myocardium*

It is important to emphasize that when there has been endocarditis there has also nearly always been rheumatic infection of the muscle, and that the after-effects of this are generally much more important. The characteristic lesion, which also occurs in the synovial membranes and elsewhere, is the submiliary nodule. There is a fibrinous matrix surrounded by large cells which are often elongated and fusiform and have several nuclei, and by fibroblasts, plasma cells, and lymphocytes. These nodules are generally near the arterioles and thrust aside the muscle-cells, which thus become damaged as the nodule is replaced by fibrous tissue. They are specially common in the left ventricle.

*Production of
stenosis*

Later, especially if there are repeated recurrent attacks, as is unfortunately so common in juvenile rheumatism, the thickening of the whole valve increases, and the cusps become united and contracted with the production of stenosis. In the mitral valve this usually becomes the most important feature; but owing to the different size and shape of the valve cusps in the aortic valve the stenosis, which is often present, most commonly does not reach such a stage as to be of clinical importance: in some cases, however, it may become extreme.

Calcification

The narrowing may be brought about by thickened adherent and calcified cusps making a diaphragm that projects into the lumen, or by a combination of this and contraction of the aortic ring. Calcification is by no means uncommon in the older patients, though it is not so common as in the atheromatous cases.

(b) *Bacteriology**Organisms
responsible*

The exact part played by the streptococcus or by the streptodiplococcus of Poynton and Paine is not yet clearly established, and there is much clinical evidence that some constitutional factor is also of importance. Exceptionally the pneumococcus or gonococcus may produce a similar simple endocarditis, but this is so rare as to be of little practical importance. It is not common for them to produce valvular disease of any sort,

but when they do it is more likely to be of the malignant endocarditis type and specially liable to affect the aortic valve.

(2)—Syphilitic Group

The underlying lesion in every syphilitic case is syphilitic aortitis; this is specially liable to affect the first part of the aorta, where the blood discharged from the left ventricle impinges on the aortic wall. The process is therefore prone to spread to the aortic valves. The morbid changes in the wall of the aorta have been described in the article ANEURYSM and need not be repeated (see Vol. I, p. 506). In every case of syphilitic aortic regurgitation there will be aortitis; in some cases this will have led to generalized dilatation of the aorta or to a localized aneurysm, and in others the process will have spread to the mouths of the coronary arteries producing angina pectoris.

The morbid changes in the aortic valves are quite different from those caused by rheumatism. Although there is much fibrosis and the valve cusps become greatly thickened, this is the final stage of a process with localized necrotic changes, and there is so much destruction that the edges of the cusps appear contracted and distorted and almost as if they had been worn away. This is well shown in Fig. 46, which also demonstrates the sharp line of demarcation between the healthy aorta and the patch of syphilitic aortitis. Aortic stenosis never develops from the syphilitic process alone, although sometimes atheromatous changes superimposed on an old aortitis may lead to this; nor is the mitral valve affected.



FIG. 46.—Syphilitic aortitis and syphilitic disease of the aortic valves producing aortic regurgitation. The destructive nature of the valve lesion, and the sharp line of demarcation between the healthy aorta and the patch of syphilitic aortitis affecting the first part of the aorta, are well shown

Aortitis

Changes in valves

(3)—Atheromatous Group

Although atheroma is distributed throughout the course of the aorta more evenly than aortitis, it often affects the first part and the aortic valves; thus in elderly patients, especially in those over sixty, it is an important cause of stenosis and regurgitation. As atheroma is primarily a disease of the intima, the degenerative changes in the elastic and

Site

Morbid changes in vessel walls

muscular layers of the media generally following later, there is not the same degree of destruction of the valve cusps, and very free regurgitation is much less likely to be found than in the syphilitic cases. More often there is stenosis, sometimes of a high degree, and here it is not due to fibrotic narrowing of the aortic ring, but to thickening and adherence of the valve cusps which have become hardened by the deposition of calcareous matter with the production of a rigid shelf projecting into the aortic opening. This picture may be present in an extreme form without much atheroma of the aorta (see Fig. 47);



Calcification

FIG. 47.—High-grade stenosis of the aortic valve with extensive fibrosis and nodular calcification. From a patient who died suddenly at the age of 48; he had no symptoms until two years before his death, when mild anginal pain developed. This type of change is fairly common in men of about 40 to 50 years of age (see p. 349)

the appearance then is that of a valvular lesion resulting from malignant endocarditis with subsequent healing and fibrosis and calcification, but there is nothing in the patient's history to correspond with this sequence of events, and usually the onset of symptoms has been quite insidious.

Calcification is present in a large number of the cases of high-grade aortic stenosis, and the views here quoted are largely based on four recently published series of such cases—namely, Cabot; Christian; Gibbs; and Margolis, Zielleson, and Barnes. It probably follows on ischaemia due

to inflammatory or atheromatous changes in the arterioles of the aortic ring, leading to endarteritis of the nutrient arteries of the valve cusps. The changes are generally confined to the valve ring and its extensions into the commissures, the cusps, and sometimes the anterior mitral leaflet. In the atheromatous cases calcification nearly always plays an important part but it is only present in about half the rheumatic cases. Sometimes the opening has been reduced to a very narrow point hardly larger than the mouths of the coronary arteries, and it is surprising how the circulation has been carried on for so long.

(4)—Malignant Endocarditis

When organisms succeed in lodging on the valves, an extremely serious condition follows. It is specially liable to happen when the valves are already diseased from old rheumatic endocarditis and also, less fre-

quently, when there are congenital abnormalities of the valves; but sometimes this pathological process starts in valves that were previously healthy. One very curious fact is the liability of congenital bicuspid valves to be affected.

The appearance is very characteristic. Instead of the small vegetations seen on the valves in simple endocarditis there may be large masses the size of a mulberry, of irregular shape and consistence, parts being recent fibrinous deposits and parts being already organized. The vegetations may spread over the endocardium as well as over the valves, but this takes place mainly on the walls of the auricle. As well as the large irregular vegetations (which are constantly liable to break off and give rise to emboli) the valve cusps may disintegrate and break off in pieces or perforate. Even when the valves are broken away, the appearance is very different from syphilitic aortic regurgitation: the valve cusps are thickened but still recognizable as cusps from which a piece has been torn away, whereas in syphilitic regurgitation the valve is so thickened and puckered as to be almost unrecognizable and looks more as if it has been worn away.

*Appearance
of
vegetations*

(5)—Congenital Group

The two types of congenital heart disease which are important here are bicuspid aortic valves and subaortic stenosis. Bicuspid aortic valves very rarely become incompetent merely because of their number, but they are unduly liable to become the seat of malignant endocarditis or of atheromatous disease at an unusually early age. In congenital subaortic stenosis the constriction is caused by a fibrous ring below the valve which is a persistent remnant of the bulbus cordis. Coarctation of the aorta is discussed elsewhere (see p. 217) and need only be mentioned here because the slighter cases may come under observation as apparent aortic stenosis.

*Bicuspid
aortic valves*

*Subaortic
stenosis*

4.—CLINICAL PICTURE

(1)—Aortic Regurgitation

The clinical picture of advanced aortic regurgitation is one of the most characteristic in medicine. As the patient enters the room, the throbbing pulsation of the carotid arteries may be visible in the neck, and a finger on the wrist may at once detect the characteristic pulse. Corrigan (1832) described the features of this pulse, especially the sudden drop without any sustained plateau, and compared it with the water-hammer, a toy then in vogue in which water enclosed in an exhausted tube fell with a thud from end to end at each turn of the tube. In addition there is often pallor, and capillary pulsation may be detected (see p. 350).

Pulse

The patient may complain of palpitation, the forcible pulsation making him unduly aware of his heart-beat, or of giddiness and faintness due to the sudden fall of pressure during diastole; and these are the only symptoms which can be attributed directly to the incompetence of

Symptoms

the valves. More often, however, palpitation, giddiness, or faintness does not point to organic heart disease, dyspnoea being the main complaint of those with this condition.

In some younger patients medical advice is sought on account of the rheumatic infection, and the aortic disease is first suspected from the physical signs. In a larger number the active process has ceased and the symptoms are due to the residual heart disease. Not only is dyspnoea the main complaint in this group, but the degree of dyspnoea and the response to an exercise-tolerance test, or, better still, the amount of work which can be undertaken without the production of undue dyspnoea, will as a rule form the best guide to the prognosis and treatment. Or the patient may be in a later stage with signs of congestive heart failure, with paroxysmal dyspnoea, or with angina pectoris; the presence of aortic disease has then ceased to dominate the picture and the course, prognosis, and treatment are discussed under ANGINA PECTORIS, Vol. I, p. 556, and HEART FAILURE, p. 376.

The possible symptomatology therefore covers almost the whole field of cardiology. Often the aortic disease is detected only by physical examination, though it may have been suspected; sometimes there will be the complete clinical picture of free regurgitation and the diagnosis may be made at sight.

*Stage of
compensated
valvular
disease*

The majority of patients seen fall into the middle stage of the disease, with more or less compensated valvular disease, the stage of infection passed, and that of heart failure not yet reached. The pulse pressure and the size of the heart are perhaps the two most useful physical signs in estimating the patient's condition; the symptoms and exercise-tolerance have already been mentioned in this connexion. The size of the heart is most important, because the pressure measures only the degree of regurgitation through the valve, whereas the size of the heart roughly measures both this and the amount of myocardial damage as well.

*Pulse
pressure*

A record of the pulse pressure (see Vol. II, p. 507) is useful, because clearly if it is less than 50 the degree of regurgitation cannot be very great and alone is not of great importance, whereas a pulse pressure above 100 mm. Hg adds considerably to the work of the heart. It also serves as an exact measure in helping to decide some years later if there has been any further progress of the valvular leak. The exact amount of blood regurgitated is not known; but observations in cases of arterio-venous aneurysm suggest that it may be as much as half of the total amount expelled by each systole, and this would mean that the work of the heart was doubled.

*Syphilitic
group*

The aetiological groups show well marked differences. In regurgitation due to syphilis the average diastolic pressure is about 60 and the average pulse pressure more than 100 mm. Hg; it was between 70 and 110 in two-thirds of the cases in my series. In the rheumatic cases the diastolic and pulse pressures are on the average about equal, and therefore half the systolic pressure, i.e. about 140/70 instead of 120/80.

Rheumatic

The atheromatous cases occupy an intermediate position: in them stenosis is often the most important effect of the valvular disease, but when it is not the pulse pressure is about 80; these are averages made of course from very diverse figures. The average diastolic pressure is higher in this group, being about 90, because there has often been an increase of blood-pressure quite apart from the valvular disease.

The size of the heart is, after the symptoms, the most important single measure of the patient's state, and radioscopy is valuable not only for its more precise measurements but because it provides another exact standard of comparison for future years. If the enlargement is only slight the outlook is generally good and a fairly active life may be allowed; if the enlargement is great a more invalid life is generally indicated, though sometimes a patient with an enormous heart will manage sedentary work for many years; with moderate enlargement it is more difficult to decide; this subject is discussed in more detail on page 347.

The characteristic enlargement is to the left, and the apex of the heart is broadened by the hypertrophy of the left ventricle (see Fig. 48).

(2)—Aortic Stenosis

The full picture of aortic stenosis is met with less frequently. Pallor, faintness, syncopal attacks, or angina pectoris may suggest the possibility, although only a small proportion of patients with any of these complaints have aortic stenosis. The pulse is the most characteristic feature, the slow rise and the sustained plateau being more important than the small volume, for of this there are many other causes. The pulse pressure may be very small, e.g. the systolic pressure may be 100 and the diastolic pressure 80 mm. Hg, and then there are likely to be symptoms

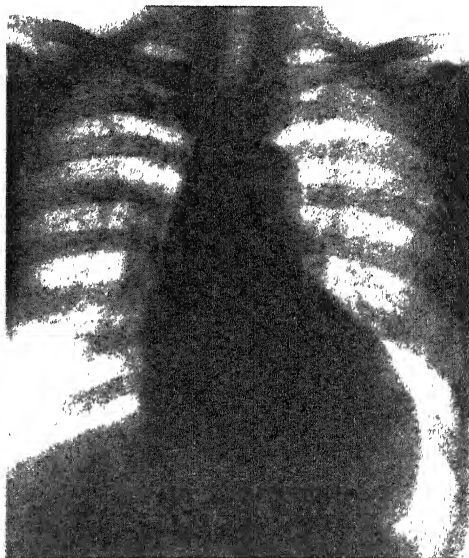


FIG. 48. — Teleradiograph of heart from a man aged 48 with syphilitic aortic regurgitation and paroxysmal nocturnal dyspnoea. There is much enlargement of the left ventricle, shown both in the increase of the transverse diameter of the heart and in the broadening of the left ventricle. The aorta shows some general dilatation, but no aneurysm

Size of heart

Pulse

Pulse pressure

of cerebral anaemia. In pure aortic stenosis the characteristic enlargement of the left ventricle is less (see Fig. 49).

Rheumatic group

The aetiological groups differ again in this feature: in the rheumatic cases pure aortic stenosis is rare and when it is found the pulse pressure is low; but when there is aortic incompetence the signs of stenosis often make little difference to the blood-pressure. Rheumatic aortic stenosis

does not usually progress far enough to prevent free regurgitation, and often an obvious water-hammer pulse is present with signs of stenosis and incompetence. In the atheromatous group the average pulse pressure was just above 50 in my cases when there was aortic stenosis, showing that the stenosis is not as a rule of a very high grade, but in many patients the stenosis had progressed far enough to lead to a very low pulse pressure with symptoms of cerebral anaemia or actual syncopal attacks as an important part of the picture.

Atheromatous group



Slight degree of stenosis

FIG. 49.—Teleradiograph from man aged 50 with aortic stenosis and slight incompetence and anginal pain. The heart is enlarged to the left, but to a much smaller extent than in most cases of aortic regurgitation. The curve easily seen in the aorta is due to degenerative atheromatous changes, although the prominence to the right of the first part of the aorta alone might suggest syphilitic aortitis

In the minority of patients with this classical picture the aortic stenosis is specially important. In the majority, i.e. those who do not show this picture, the signs of aortic stenosis will be found on physical

examination (see p. 352), and, especially with rheumatism, there will be aortic regurgitation also, masking many of the signs and symptoms. It has been said that aortic stenosis is the least serious form of valvular disease. This old-fashioned view depends on a ready diagnosis of stenosis from a systolic murmur without a thrill. Often in a rheumatic case with regurgitation and a systolic murmur without a thrill, post-mortem examination confirms a diagnosis of some degree of aortic stenosis, but it is of low grade and generally of little significance.

More severe stenosis

When there is a thrill, even if the associated regurgitation prevents the development of the characteristic pulse of stenosis, there is usually a higher and clinically important degree of stenosis. In younger rheumatic

patients it generally means a severe infection in the past and so, other things being equal, a greater degree of myocardial damage. In the middle-aged and elderly it is generally due to pure atherosclerosis or sometimes to sclerosis and calcification developing in an old rheumatic lesion; the presence of stenosis then raises special dangers.

(3)—Angina Pectoris and Syncopal Attacks

These two conditions must have a special place in the clinical picture of aortic valvular disease. One of the dangers referred to is the involvement of the mouths of the coronary arteries in the sclerotic process, giving rise to attacks of angina pectoris. The occurrence of angina pectoris and syncopal attacks and their important bearing on the course and prognosis are dealt with in a separate section (see p. 349). Although patients with free aortic regurgitation often feel faint and dizzy, fainting attacks with loss of consciousness are little if at all more frequent with them than with those without heart disease; when they do occur they are not of special significance, and reference here is only to the attacks in which consciousness is lost absolutely suddenly.

Coronary involvement

(4)—The Rhythm of the Heart

Fibrillation does not occur with aortic disease nearly so often as with mitral stenosis; but, as aortic and mitral disease are often combined,

Fibrillation

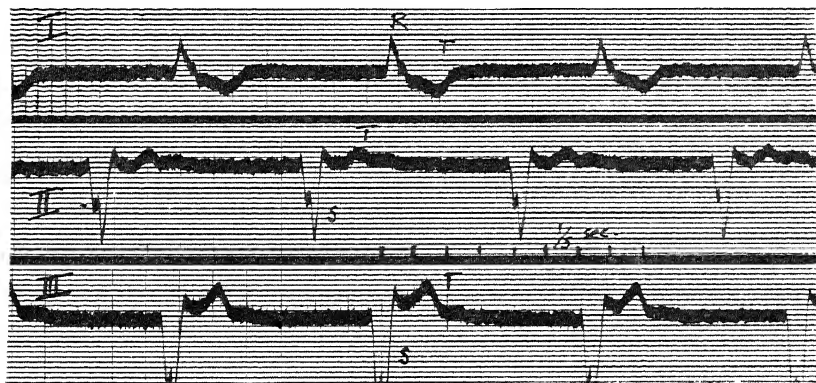


FIG. 50.—Electrocardiogram showing the common type of bundle-branch block affecting the left branch of A-V bundle; from a man aged 68 with rheumatic aortic stenosis and incompetence. This is an unusual combination of rhythm, as auricular fibrillation and complete heart-block are present as well as the left bundle-branch block

about one quarter of all cases of rheumatic aortic disease have auricular fibrillation; with pure aortic regurgitation (rheumatic), fibrillation is less frequent but is found in about 5 to 10 per cent of cases. With other aetiological types fibrillation is much less common, though it sometimes occurs in the atherosclerotic group. Extrasystoles are often found

Extrasystoles

(15 per cent) but are not generally of much importance, except that in some of the younger patients they may represent a recurrent rheumatic infection. Paroxysmal tachycardia is not rare.

*Paroxysmal
tachycardia*

Heart-block

More important is the association between aortic disease and heart-block. Complete heart-block is present in only a small proportion of the subjects of aortic disease, for it is not a very common condition; but looked at from the other point of view nearly one quarter of all those with heart-block have rheumatic or syphilitic disease, generally of the aortic valves.

*Bundle-
branch
block*

About one-third of the cases of bundle-branch block are similarly associated with aortic disease—the greater number with rheumatic aortic stenosis, the smaller number with syphilitic aortic regurgitation. The bundle-branch block is nearly always of the common type affecting the left branch of the A-V bundle (see Fig. 50).

(5)—Electrocardiographic Changes

In addition to the heart rhythm the changes in ventricular preponderance and in the T-waves are of interest. Left ventricular preponderance

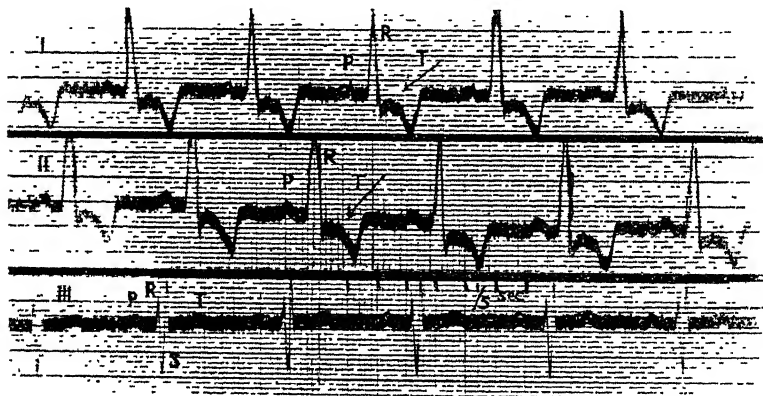


FIG. 51.—Electrocardiogram showing left ventricular preponderance with sharply inverted T-waves in leads I and II. From a man aged 67, with atheromatous aortic stenosis and incompetence and angina pectoris

*Character-
istics of
electro-
cardiograms*

with some inversion of T in lead I, alone or in lead II as well, is the common finding, but is only present in a proportion of cases (see Fig. 51). High-grade aortic stenosis is specially often associated with this picture with sharp-pointed inversion of the T-waves, sometimes even in all three leads. Some American series have been published showing that deep inversion of the T-waves is an unfavourable prognostic sign; no doubt this is true statistically, but in my experience there is too much variation for it to be a very useful practical point.

The electrocardiographic findings were carefully considered in my series, and 200 cases with aortic disease were available from this point

of view. Of those with pure aortic disease, whatever the aetiology, inversion of T 1, alone or with T 2 also, was found in nearly half (see Fig. 51), and left ventricular preponderance was present in more than half; and, as might be expected, right preponderance was hardly ever found. Among the rheumatic and syphilitic patients curves of unusually high voltage are not uncommon, and curves of low voltage are rarely found; among the atheromatous patients both these varieties occur frequently. An analysis of these electrocardiographic findings is given in Tables III. and IV.

TABLE III.—Percentage of Cases showing Ventricular Preponderance in the Electrocardiogram

AETIOLOGY			RHEUMATIC AORTIC AND MITRAL	AORTIC ONLY	SYPHILITIC AND ATHEROMATOUS
Right preponderance	—	—	12	2	1
Normal	—	—	65	47	41
Left preponderance	—	—	23	51	58

TABLE IV.—Percentage of Cases showing Inversion of the T-Wave

AETIOLOGY			RHEUMATIC AORTIC AND MITRAL	AORTIC ONLY	SYPHILITIC AND ATHEROMATOUS
Inverted T 1	—	—	7	22	19
Inverted T 1 and 2	—	—	3	12	18
Inverted T 2 and 3	—	—	5	7	7
Normal	—	—	85	59	56

(6)—Coarctation of the Aorta

This condition is dealt with on page 217, and also under the title *Types* ARTERIAL DISEASE AND DEGENERATION, Vol. II, p. 62.

5.—COURSE AND PROGNOSIS

Contrary to the views expressed in many books it is impossible to give a prognosis of aortic regurgitation or stenosis as such. If regurgitation is due to malignant endocarditis affecting the aortic valve, the patient is not likely to live more than a year, and the period may be much shorter. If aortic regurgitation is due to syphilis, and if there are already symptoms of cardiac embarrassment, the average duration of life is no more than two years; if there are few cardiac symptoms and the

*Relation of
pathogenesis
to prognosis*

diagnosis has been made early, life may be prolonged for ten years. If regurgitation is due to atheroma, the patient is probably older, and apart from grave cardiac symptoms the prognosis must be made on a careful consideration of the state of his arteries elsewhere, especially in the brain, and of the state of his kidneys as well as of his heart. If regurgitation is due to rheumatism, the prognosis is much better; some patients may live and work for forty years, and perhaps the average duration of life is over twenty years, but there are often present other features indicating a less favourable prognosis.

*Two groups
with grave
prognosis*

From the morbid changes which underlie aortic disease it is evident that there are two groups of patients in whom the possibility of a rapid downhill course must be specially borne in mind. Free aortic regurgitation, especially if syphilitic, is associated with a high degree of hypertrophy and dilatation of the left ventricle, and therefore sooner or later the patient will suffer from increasing dyspnoea with the risk of congestive heart failure or of paroxysmal nocturnal dyspnoea.

The second group consists of those with anginal pain; the proximity of the aortic valves to the orifices of the coronary arteries makes it easy for the same pathological process to affect both, and therefore angina pectoris is a common association: indeed aortic stenosis is the most likely finding if a young patient under thirty-five complains of true angina. The frequent association of aortic regurgitation and syphilitic aortitis is another common cause of cardiac pain in these patients.

The cause of the aortic disease is therefore the most decisive factor in the prognosis, and the three main groups must be considered separately.

(1)—Rheumatic Group

*Guides to
prognosis*

The first question is whether there is active rheumatic carditis or whether the patient is suffering from the after-effects of such an infection—a scarred valve with regurgitation or stenosis and a damaged myocardium. Apart from pains in the joints or chorea, the heart-rate and the temperature are the main guides, and it is often wise to have these charted night and morning for a week or two. If the mother can be trusted, her record is most likely to avoid the confusion with nervous tachycardia. A single observation of a temperature of 100° F. in a nervous child at out-patients is no conclusive evidence of infection, though it needs investigation. The sedimentation-rate or the pulse-rate taken during sleep will often help in doubtful cases. The presence of active rheumatism indicates the treatment, the type of valvular disease present being for the moment of little importance.

*Regulation
of activity*

In the absence of active rheumatism the two most important points are to take all possible steps to prevent further recurrence and to assess the degree of damage to the heart so as to regulate the patient's activity in the way that will be best for his future. Taking a long view it is nearly as important to prevent too little activity or even a prolonged life of invalidism as it is to prevent the patient from doing too much.

The sex and social status of the patient and the temperament of the parents must be taken into account in giving this advice.

In my experience a rheumatic child who develops a good colour and puts on weight has thrown off the greatest danger of another attack of rheumatism. A child who remains thin and pale, not necessarily anaemic, is still in danger of a relapse and must be treated with special care even if he is not actually suffering from subacute rheumatism. Only too frequently a patient with well-developed valvular disease denies any rheumatic history but readily admits a long period of treatment for 'anaemia and debility'. The idea that subacute rheumatism is less serious than rheumatic fever is dangerous. With considerable experience of a particular child and of its relatively slight liability to rheumatic carditis it may sometimes be justifiable to treat a minor relapse lightly, provided that the child is carefully watched; but a first attack of even the mildest rheumatism must be regarded as a serious disease. (See also p. 248 and RHEUMATIC INFECTION, ACUTE.)

*General
appearance
of child*

With these considerations in view it is difficult to speak of the course and prognosis of a particular case of aortic disease in a child, because the chance of further damage is the outstanding factor. As he approaches and passes the age of twenty, however, the chance of recurrent attacks and of fresh injury to the heart diminishes, though it is many years before it disappears.

In assessing the patient's condition and the damage already done, the size of the heart is much the most valuable single point. To my mind the importance of the extra work induced by aortic regurgitation (though this may certainly be considerable) has been exaggerated and the degree of hypertrophy caused by this alone is not extreme. The size of the heart is more important, because it is a rough measure of the amount of myocardial damage. For instance, one man has attended the Heart Hospital from time to time for nearly thirty years with signs of free aortic regurgitation, a loud aortic diastolic murmur, capillary pulsation, and a wide pulse pressure. He has throughout led a normal easy life and earned his living in a sedentary occupation, and even now his heart is little if at all enlarged. This presumably represents an attack which fell heavily on the aortic valve and unusually lightly on the myocardium, so that the healthy heart muscle has been able to deal easily with the additional work caused by the aortic regurgitation.

*Significance
of size of
heart*

When the cardiac enlargement is only slight, the outlook is often extremely good and, if heavy manual work is avoided, may remain so for twenty or thirty years. If there is greater enlargement of the heart, more care will be needed in the choice of an occupation and in the amount of exercise taken, but still the outlook often remains good for many years. When the heart is greatly enlarged, the capacity for work and the expected duration of life are both much reduced. In the past too much attention has been paid to the mere presence of aortic disease and too little to the condition of the heart as a whole.

Finally, if congestive failure has begun to appear with or without

auricular fibrillation, or in an older patient if there is angina pectoris or cardiac asthma, the last stage (though sometimes a relatively long last stage) has been reached, and the course and prognosis will be guided by these considerations; the valvular disease present is no longer of the same significance.

*Type of
valvular
disease*

The type of valvular disease is also of importance. Aortic regurgitation is the most frequent lesion, but in more than half the cases (see p. 333) mitral stenosis is also present and its signs and symptoms may predominate. The coexistence of mitral stenosis makes the onset of auricular fibrillation a greater future risk, though this arrhythmia also occurs with pure aortic disease.

*Aortic
stenosis*

Aortic stenosis in some degree often accompanies regurgitation, but in rheumatic patients, especially in the younger ones, it rarely reaches such a high degree as to produce the clinical picture of stenosis. In general it is true that any additional valvular lesion adds to the gravity of the prognosis, and this is true not only because of the added load so produced but also because it generally indicates that the original attack was more severe and probably that the myocardium has suffered greater damage.

Generally therefore rheumatic aortic stenosis is of serious significance in a young patient, its gravity being related to the size of the heart; but if all other signs and symptoms are favourable aortic stenosis is compatible with a good prognosis. In older rheumatic patients the original valvular changes have often been made worse by subsequent atheroma and calcification, and the course and prognosis are much the same as if they belonged to that group.

(2)—Syphilitic Group

*Syphilitic
aortitis*

These cases can be divided into two main groups. In one the diagnosis has been made early, by a routine examination, because of a known syphilitic history or of palpitation or digestive symptoms. Here the lesion is really syphilitic aortitis with early involvement of a valve cusp, and with efficient treatment the patient may sometimes get on well for ten years. I think that I have seen one such early case of aortic regurgitation cured. In the other group the patient seeks advice for cardiac symptoms, most often angina, paroxysmal nocturnal dyspnoea, or congestive failure. The position is much more serious and the average duration of life is hardly more than two years, though some patients with slight angina or dyspnoea only may do well for five years or more. In all such cases the possibility of sudden death must be remembered; moreover, the disease may suddenly and without any apparent reason run a rapid downward course, with congestive failure or nocturnal dyspnoea.

*Relative
importance
of signs and
symptoms*

There is an apparent paradox about syphilitic aortic disease. Early diagnosis depends almost entirely on physical signs, and even a short faint diastolic murmur which reveals aortitis may be of immense importance; but at a later stage the symptoms quite overshadow the physical

signs, the degree of regurgitation or of dilatation of the aorta and even the size of the heart being unimportant compared with the symptoms in assessing the state of the patient.

In uncomplicated aortic regurgitation without much cardiac enlargement the progress may often be fairly good even for five or ten years. provided that work can be reduced and that treatment is adequate. Even anginal pain, so long as it is not very easily provoked, may be held in check by treatment. The dilatation of the aorta, which is nearly always present, is not very important; the association with aneurysm, also common, is discussed elsewhere (see Vol. I, p. 515). *Aortic regurgitation*

If there is much dyspnoea, or enlargement of the heart, or a large aneurysm, or if angina is easily provoked, the limitations called for will be more severe and the course of the disease is likely to be shorter. If congestive failure or paroxysmal nocturnal dyspnoea is present, the patient is in some danger, even in the near future, and unless complete rest relieves his symptoms quickly he will probably have to live an invalid life. It is uncommon for such a patient who has had congestive failure to be capable of any but the easiest work again. *Presence of complications*

(3)—Atheromatous Group

In this variety aortic stenosis is more frequent than regurgitation. When the stenosis is slight and the pulse pressure not much reduced, or when there is regurgitation without much cardiac hypertrophy, the lesion is not in itself of serious significance. But the patients in this group are usually older, and their general condition must be considered in connexion with the course and prognosis.

When congestive failure is present and associated, as it usually is, with normal rhythm, the outlook is not good, though on the whole better than in the syphilitic cases; in the smaller number in which the failure has been provoked by auricular fibrillation the prognosis is better.

Angina pectoris is very common in this group, and it is certainly more serious to have angina and aortic disease than angina alone. Some patients, especially men about fifty, have well marked signs of high-grade aortic stenosis generally without any signs of incompetence, and they often have severe angina pectoris. Many of them have no history of past valvular disease, although sometimes perhaps it has resulted from atheromatous and calcareous changes in a valve that was only slightly damaged by previous rheumatism. This is another group in which nothing except the lightest work must ever be undertaken. In deciding on this advice paroxysmal nocturnal dyspnoea should be given about the same significance as anginal pain. *Angina pectoris*

Sometimes in this group and more rarely in the others there is a history of syncopal attacks. The loss of consciousness is absolutely sudden, so that the patient may even fall in the street, but it is of short duration and not as a rule followed by epileptiform convulsions. The mechanism of such attacks is not quite clear, but they are very liable to recur and to prove fatal. One man was seen at hospital and advised *Syncopal attacks*

to give up his work but refused to do so. He was found dead in the road one evening, having fallen off his bicycle; a friend had seen him passing in his usual health a few minutes before. The degree of lumpy calcification in the aortic valves, shown in Fig. 47, was extreme, although there was no past history of any infection. Again and again I have been surprised at the length to which the disease of the aortic valve has progressed before any symptoms have become manifest.

Conclusion

Perhaps in this and the previous section, the gravity of the prognosis has been rather over-emphasized. Often the result is disappointing in spite of all that can be done; but this is not always so. One patient seen seven years ago with high-grade aortic stenosis and some regurgitation, and with frequent angina pectoris and paroxysms of tachycardia, was written for after four years. He had not left his room for two years owing to the frequency of his pain and paroxysms, but in spite of this, after a period of rest in hospital and progressive exercises to enable him to manage stairs again, he has been able to resume a normal quiet life, using trinitrin tablets whenever he has any pain. The condition of his heart is little if at all changed during the last seven years and he is able to lead a far more active life.

6.—DIAGNOSIS

It is not sufficient to make a diagnosis of aortic incompetence or stenosis. The prognosis is so different in the various aetiological groups that it is essential to consider also whether it is rheumatic, syphilitic, or atheromatous, or due to one of the rarer causes. In the absence of congestive failure, paroxysmal nocturnal dyspnoea, or angina, any one of which obviously places the patient in the last most serious stage of this progressive disease, the degree of dyspnoea, the extent of the regurgitation, and the size of the heart must be included in the diagnosis as the main factors in assessing the course, prognosis, and treatment.

Diagnosis of regurgitation

Aortic regurgitation can be diagnosed whenever there is a diastolic murmur best heard in the aortic area. This always indicates regurgitation, and is sufficient by itself to justify the diagnosis, the presence of a water-hammer pulse and of capillary pulsation showing a greater degree of regurgitation. These two signs are not the best evidence of the presence of aortic regurgitation, though together they may be almost conclusive. Capillary pulsation occurs whenever the vascular bed is widely opened, e.g. normally after exercise on a hot day; the water-hammer pulse may be simulated by the large swinging pulse in hyperthyroidism, or in the elderly patient with an atheromatous aorta; though actually the sudden characteristic drop is not found here, and the resemblance is produced only by the large pulse pressure in each case. A sign which has not been described but which I have found useful is an unusually sharp line of demarcation between the red of the lips and the pallor of the face.

A new sign of aortic regurgitation

With free regurgitation the long blowing diastolic murmur is easily heard, and probably the diagnosis has already been suspected on the appearance of the patient. With slight regurgitation the diastolic murmur is less certain to attract the listener's attention; and examination of a cardiac case is not complete until the aortic area has been specially auscultated for a diastolic murmur. The patient should stand or sit up and hold his breath at the end of expiration. This may reveal a diastolic murmur which would otherwise be difficult to hear. The murmur is generally best heard in the second and third intercostal spaces just to the right of the sternum and is conducted downwards. With free regurgitation it may be conducted very widely and may occasionally be audible to the patient.

With syphilitic or atheromatous aortic regurgitation, the murmur will always be heard best to the right of the sternum, probably because the aorta is often dilated to the right. With rheumatic aortic regurgitation it may be audible in the same site but may be heard best over the sternum or in the third space to the left of the sternum, as the aorta is probably not dilated. It may then be difficult to exclude pulmonary regurgitation, but this is a rare condition except as a complication of a rheumatic heart with mitral and aortic disease in addition, or when malignant endocarditis is superimposed on congenital pulmonary stenosis. The enlargement of the heart to the right or to the left, the shape on radioscopy, and the general features of the case must then decide the diagnosis. A thrill which can be felt in the aortic area is generally systolic, but sometimes a diastolic thrill accompanies free aortic regurgitation, particularly in syphilitic cases.

*Size of
murmur*

The presence of free aortic regurgitation may render the diagnosis of mitral stenosis more difficult. X-ray examination may be essential to settle if there is mitral stenosis, and in the absence of a clear rheumatic history this may be very important in settling the aetiology. The diastolic murmur may be conducted widely down to the apex and, though it is generally louder in the aortic area, it may sometimes be heard first or most easily at the apex. An aortic murmur will generally be loudest at the beginning of diastole and will fade away during diastole as the pressure in the first part of the aorta drops, in contrast to the mitral murmur which often increases in intensity throughout diastole ending in the characteristic rumbling presystolic murmur. Austin Flint (1862) described the presystolic murmur associated with his name, heard in the mitral area but due entirely to the disease of the aortic valves and associated with a normal condition of the mitral valves. It is not uncommon and may be accompanied by a presystolic thrill; it is probably due to relative mitral stenosis from the enlarged left ventricle, but the stream of regurgitant blood impinging on the mitral valve before it is taut is an alternative explanation.

*Mitral
stenosis*

*Diastolic
murmur*

*Austin
Flint's
presystolic
murmur*

The opposite problem of a mitral diastolic murmur conducted upwards, so that it is heard in the second and third intercostal spaces to the left of the sternum, may also cause difficulty and suggest wrongly that there

*Graham
Steell
diastolic
murmur*

is aortic regurgitation or pulmonary regurgitation (Graham Steell murmur).

Radioscopy

The presence or absence of a water-hammer pulse or capillary pulsation and other features of aortic incompetence will help in the doubtful cases, and in the presence of free aortic regurgitation enlargement of the heart to the right may often be the most reliable clinical sign of mitral stenosis. Similarly in an obvious case of mitral stenosis much enlargement to the left may be a confirmatory sign of aortic regurgitation. Radioscopy is of great help; the presence of a large left ventricle or of a dilated left auricle, especially the backward enlargement shown in the oblique position and emphasized by the passage of barium down the oesophagus, may clinch a doubtful diagnosis. Often when aortic regurgitation and mitral stenosis are both present one or other may have had the most obvious effect on the shape of the heart and on the general symptoms, and I have found it useful to indicate this in the diagnostic summary by bracketing one or other of the two headings in appropriate cases.

*Diagnosis
of aortic
stenosis*

The diagnosis of aortic stenosis is not so simple as that of aortic incompetence, although in cases of high-grade aortic stenosis it may at once be suggested by the feel of the pulse, both the slow rise and the sustained plateau being readily appreciated by the finger. A systolic murmur is often present as well as the diastolic and may indicate nothing more than some roughening of the valves. Whenever there is a systolic murmur, a special search should be made for a systolic thrill, and the rougher the murmur the more confidently may it be expected. The patient should sit up and hold his breath for as long as possible at the end of expiration, while the hand is placed in different positions over the upper end of the sternum. Sometimes firm pressure and sometimes light pressure will elicit it best. A thrill above the clavicles is a less certain sign, as it may be produced by pressure on the artery, e.g. by enlarged glands, but if a thrill can be felt easily above the clavicles a very careful search should be made for one over the sternum.

*Method of
eliciting
systolic thrill*

*Aortic
stenosis with
incompetence*

The combination of aortic stenosis and incompetence is much commoner than pure aortic stenosis. It is sometimes said that only the expert should diagnose aortic stenosis in the absence of aortic incompetence, but the intention of this warning can be expressed better by the following statements. In the absence of aortic incompetence, stenosis should never be diagnosed unless there is a systolic thrill as well as a murmur, or the characteristic pulse of aortic stenosis, or both. In the presence of aortic incompetence stenosis may be suspected even without a thrill if there is a very rough systolic murmur, especially if the pulse is less characteristic of aortic incompetence than would be expected from the loud diastolic murmur. The blood-pressure should always be taken as a measure of the degree of stenosis, and the pulse in both arms should be taken as a routine to detect the slighter cases of coarctation of the aorta.

The only condition in which a systolic thrill does not justify a diagnosis

of stenosis is when the aorta is much dilated and the signs are due to relative stenosis. This is nearly always the explanation when there is a systolic thrill with aortic regurgitation due to syphilis, as this does not produce aortic stenosis. If there is a systolic thrill with signs of free regurgitation in a case which is not known to be rheumatic, an X-ray examination is essential to decide if the aorta is dilated and if the type of dilatation suggests the presence of syphilitic aortitis.

Diagnosis of relative stenosis

Diagnosis of the cause must always be included, because the aetiological factor makes so much difference to the treatment and prognosis. A rheumatic aetiology may be accepted when there is (1) a clear rheumatic history, or (2) mitral stenosis even without this history. When there is mitral stenosis (confirmed by X-ray), it is unnecessary to make more than routine inquiries for a history of syphilis, and often a Wassermann test is unnecessary. No doubt pure rheumatic aortic incompetence may sometimes occur without any definite rheumatic history, just as mitral stenosis does, but such cases remain doubtful and must be fully investigated.

Diagnosis of cause

In the absence of mitral stenosis careful inquiries for any history of syphilis, a Wassermann test, and X-ray examination of the aorta must nearly always be included. A history of gonorrhoea may be important as suggesting undiagnosed and untreated syphilis, which is specially likely to be followed by cardiovascular syphilis fifteen to thirty years later. Rarely gonorrhoea may also be significant in cases of aortic regurgitation due to malignant endocarditis, as gonococci implanted on the aortic valves may start this disease: simple endocarditis due to gonococcal infection is most exceptional.

Case history Syphilis and gonorrhoea

Patients may be placed in the atheromatous group when radioscopy shows atheromatous changes in the aorta or when there are advanced arteriosclerotic changes in the brachial, radial, or retinal arteries in those who cannot be included in the rheumatic or syphilitic group. Advanced atheroma is present in about half of the cases which are neither rheumatic nor syphilitic and is probably the aetiological factor. Primary malignant endocarditis is the next most common cause, and clubbing of fingers and the presence of red blood cells in the urine must be carefully looked for. An enlarged spleen and anaemia are not equally significant, since splenomegaly may be due to an embolic infarct and anaemia is common in patients with rheumatic valvular disease. It is important that anaemia should not be overlooked, as it may be responsible for dyspnoea which can be completely relieved by treatment, whereas heart disease, which may also cause dyspnoea, can only be palliated.

Diagnosis of atheroma

7.—TREATMENT

(1)—Preventive

This depends on the cause. In the rheumatic cases the most important point is the prevention of further attacks in those who have already suffered from rheumatism once. The aortic valve may be affected in

Rheumatic cases

the first attack but is more likely to be involved in subsequent attacks, especially if they are severe. Careful and thorough treatment of minor ailments such as colds and tonsillitis, long hours in bed, the avoidance of wet shoes and damp clothes, and the prevention of damp in houses, certainly do much to prevent recurrence of acute rheumatism. Other measures for the care of rheumatic children are discussed in detail on page 250.

*Occupation:
for patients
with aortic
regurgitation*

When aortic regurgitation is already present, the choice of a suitable occupation may be regarded as symptomatic rather than preventive treatment: but, as the regurgitation alone may produce few symptoms, this can in a real sense be regarded as preventive treatment, for it may for many years ward off any significant degree of dyspnoea and the onset of cardiac failure. Ideally no patient with aortic regurgitation should earn his living by manual labour, and the longer such a patient stays at school and fits himself for a sedentary occupation the better his prognosis. With most rheumatic children the temperament makes this a favourable solution.

*Antisymphilitic
treatment*

With the syphilitic cases the good effect of antisymphilitic treatment in preventing the dilatation of the aorta when aortitis is already present gives strong grounds for the belief that more efficient early treatment might often prevent the onset of aortic regurgitation. The difficulty is the diagnosis of such cases, but an accentuated second sound in the aortic area in the absence of a raised blood-pressure, and any projection to the right in the first part of the aorta on radioscopy, may enable the diagnosis to be made early.

Almost certainly thorough treatment in the primary and secondary stages should do much to prevent subsequent syphilitic aortic regurgitation. At present (1937) there is no statistical proof that this is the case; but with the more thorough treatment which has been instituted since about 1920 it is hoped that this evidence may soon be forthcoming.

*Atheromatous
cases*

For the atheromatous cases there can be no preventive treatment, as little, if anything, is known about the cause of atheroma.

(2)—Specific and General

There is no specific treatment for aortic regurgitation or stenosis as such; and, except in syphilitic cases, there is no special medical treatment apart from that designed to deal with associated conditions such as angina pectoris or heart failure. The treatment needed entails adjustment of the patient's life to the capacity of his heart muscle and guarding this, already carrying the burden caused by the valvular lesion, against further overwork.

*Rheumatic
cases*

In rheumatic cases it is as a rule impossible to be too careful during the first twenty years of life, because the possibility of recurrent rheumatism is ever present, and the patient will probably indulge in a good deal of activity whatever restrictions are ordered. This does not mean that exercise or even organized games may not sometimes be advisable, but the patients should be watched carefully and examined

at regular intervals. After the age of twenty a more stable condition of the heart has generally been reached, and, when all the signs are satisfactory, the amount of activity and exercise allowed can often be increased. The size of the heart and the pulse pressure are the best guides to the restrictions needed in cases in which there is no obvious dyspnoea.

In more severe cases with dyspnoea on slight exertion definite periods of rest should be laid down, and the total length of working life can often be greatly increased by careful observation of the patient's capacity. In all these cases, whatever the aetiology, the avoidance of heavy meals and of any food which may cause flatulence, and a rest after meals, are of great help in relieving many symptoms. When the later stage is reached and there are early signs of congestive failure, aortic valvular disease ceases to be the objective of treatment, and the treatment should be the same as for congestive heart failure in other conditions.

In the syphilitic cases the dividing line which settles the treatment to be adopted is the presence or absence of congestive failure. Before the onset of this stage, prolonged antisyphilitic treatment, as outlined in the article on aneurysm (see Vol. I, p. 520), may be extremely effective in preventing the further progress of the disease and in prolonging life. It should, however, always be accompanied by great restrictions of previous activities, and may necessitate a change of work. When congestive failure has once occurred, it is to this that treatment should be directed; the cause may be forgotten, as antisyphilitic treatment may sometimes do harm and will never do good.

Syphilitic cases

Acute pulmonary oedema, cardiac asthma, or any form of paroxysmal dyspnoea must, like congestive failure, be regarded as a contra-indication to treatment with arsenic or bismuth. On the other hand, angina pectoris is certainly not a contra-indication and such cases often do well. The degree of activity to be allowed is discussed on page 349. Except when the work is sedentary it must always be considerably reduced. Going to bed early and resting at the week-end and, when possible, taking a day off in the middle of the week may be very helpful. The great difficulty is that so many of the patients are accustomed only to hard physical work.

Contra-indications to antisyphilitic treatment

In atheromatous cases there may be other findings of great importance, as well as those directly concerned with the heart; for example, atheromatous cerebral arteries with a high blood-pressure may be a source of danger. A large proportion of such patients have aortic stenosis, and the fibrotic and calcareous changes in the valves may also involve the mouths of the coronary arteries, so that the patients are likely to suffer from angina pectoris. Many such patients have indulged in hard manual work but, whatever the difficulties, must give this up if there have been any cardiac symptoms, for in these cases such symptoms nearly always mean serious advanced changes. A course of potassium iodide may sometimes help, but the main reliance must be placed on the reduction of activity. When angina pectoris is present, trinitrin

Atheromatous cases

tablets $\frac{1}{200}$ to $\frac{1}{100}$ grain should be taken freely at the onset of each attack of pain and sometimes as a preventive when pain is expected; frequently this remedy is looked on as something only to be used in an emergency, and the opportunity for effective treatment may be lost.

*Importance
of state of
muscle*

In all cases of disease of the aortic valves it must be stressed that the prognosis and treatment depend at least as much on the condition of the heart muscle as on the condition of the aortic valves.

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IX.—RIGHT SIDE DISEASES

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1.—DILATATION

Aetiological factors

653.] The aetiological factors in dilatation of the right heart include acute febrile diseases, such as bronchitis, diphtheria, rheumatism, and influenza: conditions associated with severe or prolonged pyrexia, such as pneumonia and scarlet and enteric fevers; various forms of anaemia; acute and chronic diseases of the coronary arteries; valvular diseases, including mitral stenosis, mitral regurgitation, pulmonary insufficiency, pulmonary stenosis, and affections of the tricuspid valve; mediastinitis; adherent pericardium; chronic pulmonary diseases, such as asthma, emphysema, pneumoconiosis, and pulmonary collapse; mechanical factors resulting from chest deformities; and pulmonary endarteritis obliterans.

The course, prognosis, and treatment of right-heart dilatation are discussed under Tricuspid Insufficiency, on page 364.

2.—HYPERTROPHY

(1)—Aetiology

654.] The commoner aetiological factors in hypertrophy of the right ventricle include diseases of the pulmonary valve, mitral stenosis, mitral regurgitation, tricuspid incompetence, chronic pericarditis, chronic mediastinitis, chronic diseases of the lungs, such as emphysema, asthma, pneumoconiosis, and fibroid tuberculosis, atheroma of the pulmonary artery, and pulmonary endarteritis obliterans. In the presence of these conditions the ventricular wall may be twice or even three times its normal thickness, and various degrees of auricular hypertrophy are associated in the process. (See also p. 222.)

(2)—Clinical Picture

Hypertrophy alone

As long as compensation continues, hypertrophy of the right heart alone is relatively free from symptoms; there may be subjective manifestations of an impaired circulatory reserve, but as a rule these are associated clinically with the primary disability, such as mitral disease or pulmonary disease, which is responsible for the hypertrophy.

Associated conditions

(3)—Course, Prognosis, and Treatment

While compensation holds good, treatment other than preventive measures, prophylaxis against rheumatism, and suitable symptomatic remedies, is not needed; but, as all the various diseases responsible for the hypertrophy are naturally progressive, ultimate dilatation and failure must be anticipated (see p. 368) and the appropriate treatment instituted (see p. 378).

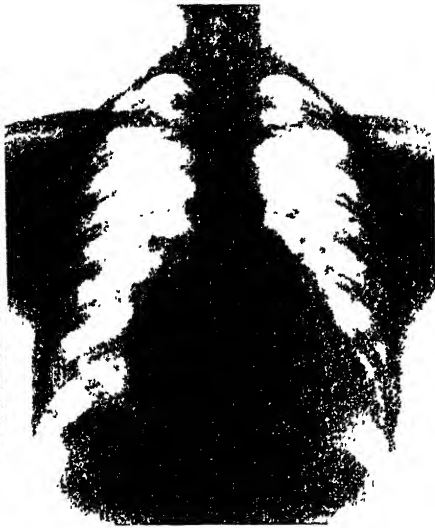
(4)—Diagnosis

Physical signs

The diagnosis depends upon physical signs and X-ray examination; the former include increased dullness on percussion to the right of the



A



B



C



D

- A. Teleradiograph from patient with mitral stenosis, right-heart failure, and tricuspid insufficiency; dilatation of right heart and pulmonary conus. B. Teleradiograph from patient with tricuspid and mitral stenosis; dilatation of right auricle and pulmonary conus. C. Teleradiograph, right oblique position; barium in oesophagus to show enlargement of the right auricle: a case of tricuspid stenosis. D. Teleradiograph, left oblique position, showing hypertrophy of right ventricle in a case of tricuspid incompetence

PLATE IV

sternum; epigastric pulsation; accentuation, possibly also reduplication, of the second sound at the pulmonary base; various degrees of stasis in the jugular vessels; and a tendency to cyanosis.

Radiological examination by the modern technique is undoubtedly the best method of diagnosing cardiac hypertrophy in all its stages; the auricles and the ventricles can be studied separately, and such abnormalities as may be present can be accurately analysed; the right auricle is seen to the best advantage in the antero-posterior (see Plate IV, A and B) and the right oblique positions (see Plate IV, C); the left oblique position (see Plate IV, D) is preferable for the assessment of right ventricular hypertrophy, and enlargement of its conus is usually well

X-ray examination

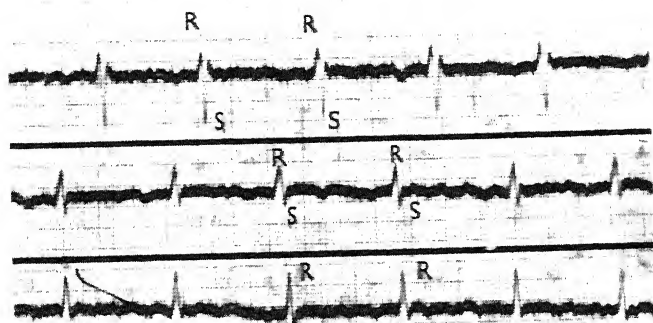


FIG. 52.—Electrocardiogram from case of mitral disease with tricuspid insufficiency; curves show right ventricular preponderance and auricular fibrillation

defined in both the antero-posterior (see Plate IV, A and B) and the right oblique views (see Plate IV, C).

In otherwise uncomplicated cases of right ventricular hypertrophy the electrocardiogram is typical of right ventricular preponderance (see Fig. 52).

Electro-cardiogram

3.—VALVULAR DISEASE

(1)—Pulmonary Insufficiency

(a) Aetiology

655.] The rarest of all the valvular lesions, pulmonary insufficiency may occur either as the result of organic disease or in a so-called relative or functional form.

Apart from congenital malformations, many structural defects have been recognized as of aetiological importance in the organic group of cases, the more prominent including malignant endocarditis, inflammatory adhesions of one or more cusps of the pulmonary valve secondary to pressure by a neighbouring aneurysm of the aorta, and, more rarely, rheumatic endocarditis.

Organic type

The functional type of pulmonary insufficiency is secondary in the large majority of cases to a progressively rising blood-pressure in the

Functional type

pulmonary circuit, the sequel to decompensated lesions of the left heart or to chronic obstructive diseases of the lungs. Recent investigations (Kountz, Alexander, and Prinzmetal), however, show that chronic pulmonary affections do not invariably produce severe hypertension or vascular derangements in the lesser circuit, although it is still generally admitted that right-heart failure, in some degree, is likely to develop as the result of extreme reduction in patency of the pulmonary vascular bed together with the fatigue of the right ventricle which characterizes chronic obstructive diseases of the lungs.

(b) Clinical Picture

The symptoms are by no means characteristic; there may be a complaint of cough and breathlessness on exertion, and in some cases haemoptysis has been recorded; otherwise the symptoms will vary somewhat according to the nature of the intercurrent primary disease, e.g. malignant endocarditis, mitral stenosis.

Physical signs

Obvious indications of right ventricular enlargement may be noted on inspection in an average case of pulmonary insufficiency. These include various degrees of epigastric pulsation and an appearance of bulging in the lower praecordia; possibly there may be a fine diastolic thrill in the pulmonary region, and a blowing diastolic murmur, which is of maximal intensity at the junction of the second left costal cartilage with the sternum, is transmitted down the left sternal margin, and usually immediately follows the second sound; a diastolic murmur indicative of dilatation and relative incompetence of the pulmonary valve ring in cases of mitral stenosis was described by Graham Steell in 1881, and for descriptive purposes this murmur is still referred to as the Graham Steell murmur; additional murmurs significant of defects in the other valves are likely to be audible in cases of relative pulmonary insufficiency: at the apex region there may be conclusive auscultatory evidence of mitral stenosis; and a blowing systolic murmur at the lower end of the sternum, in conjunction with the usually accepted characteristic manifestations of the lesion, may be taken to indicate tricuspid insufficiency (see p. 363).

Diastolic murmur

Graham Steell murmur

Systolic murmur

(c) Course and Prognosis

It has been stated that patients with pulmonary insufficiency secondary to structural disease of the valve may live a tolerably active life for years, always assuming that they are fortunate enough to escape malignant endocarditis, but that in patients with functional valvular inefficiency, a development incidental to some such lesion as mitral stenosis in its terminal stages, the outlook is definitely unfavourable.

(d) Diagnosis and Differential Diagnosis

Symptoms not specific

The diagnosis of pulmonary incompetence is, as a general rule, based on objective evidence, no symptoms being definitely specific. The more valuable indications include hypertrophy and different degrees of

failure of the right ventricle; a blowing diastolic murmur of maximal intensity at the pulmonary base; radiological appearances characteristic of dilatation and excessive pulsation in the pulmonary conus and the pulmonary arteries; and, in otherwise uncomplicated cases, an electrocardiogram typical of right ventricular preponderance.

Physical signs
X-ray appearances
Electrocardiogram

Though in many respects very similar, the murmurs of aortic and pulmonary insufficiency can usually be distinguished if the characteristic manifestations of the two lesions are adequately appreciated: the aortic murmur is conducted to the right of the sternum and may be audible in the cervical vessels; whereas the pulmonary murmur is generally loudest in the left upper praecordia, is conducted down the left sternal margin to the ensiform region, and is never transmitted to the systemic vessels; further, the aortic murmur can usually be confirmed by intercurrent phenomena, including a collapsing pulse, capillary pulsation, and hypertrophy of the left ventricle. Pulmonary incompetence is more particularly characterized by vigorous pulsation of the right ventricle and pulmonary artery, dense pulsating shadows in the lung roots on the X-ray screen, and a tendency to accentuation of the diastolic murmur in the expiratory phases.

Diagnosis from aortic insufficiency

(e) *Treatment*

Treatment is described under pulmonary stenosis (see p. 362).

(2)—Pulmonary Stenosis

(a) *Aetiology*

656.] In the large majority of cases pulmonary stenosis is due to a congenital defect (see p. 227), but lesions of the valve may be acquired in acute rheumatism and malignant endocarditis.

Congenital
Acquired

(b) *Clinical Picture*

The symptoms include breathlessness on exertion, precordial discomfort, various degrees of cyanosis, and clubbing of the fingers (see p. 178, and Fig. 25); there may be symptoms of superimposed malignant endocarditis (see p. 299) and in the terminal stages of the disease all the symptoms of tricuspid insufficiency (see p. 363).

(c) *Diagnosis and Differential Diagnosis*

The outstanding physical sign of pulmonary stenosis is a harsh and sustained systolic murmur which is of maximal intensity in the second left intercostal space at the margin of the sternum; it is usually conducted upwards to the root of the neck, but differs from the somewhat similar murmur of aortic stenosis in that it is not audible in the systemic vessels; it is generally associated with a fine systolic thrill, a second sound of diminished intensity at the pulmonary region, an epigastric thrust characteristic of right ventricular hypertrophy, and an electrocardiogram indicating right axis deviation. In addition to these signs, evidence of right ventricular dilatation and failure is likely to be obvious

Systolic murmur

Electrocardiogram

in the later stages of the disease, which may terminate with the characteristic clinical syndrome of tricuspid incompetence (see p. 363).

Differential diagnosis

From functional systolic murmur

In the differential diagnosis of pulmonary stenosis attention should be directed to conditions characterized by a basal systolic murmur. That this murmur may be a functional development is well recognized; healthy people, particularly those with thin chest walls, may develop a soft, transient, and variable systolic murmur at the pulmonary base after violent exertion. It may also be associated with the rapid pulse of fever and with the various forms of anaemia. These conditions, however, can usually be assessed without difficulty, because, apart from the quality of the murmur and the phasic variability of its appearance, there is not an associated thrill, the second heart-sound at the pulmonary base is of normal intensity, and there is no evidence of embarrassment of the right ventricle.

From aortic stenosis

A further problem of the differential diagnosis is the apparent similarity of the physical signs which characterize the two lesions, aortic and pulmonary stenosis. The quality of the murmurs may be identical, but it is noteworthy that the murmur of aortic stenosis is propagated into the cervical vessels, the second sound being diminished at the aortic base, the left ventricle being hypertrophied, and the pulse in typical cases assuming the anacrotic form. These signs differ so materially from the findings in typical cases of pulmonary stenosis that it is usually possible to establish the differential diagnosis of the two lesions with a reasonable degree of certainty.

From obstruction in the pulmonary artery

In certain circumstances the systolic murmur may point to relative obstruction in the pulmonary artery as opposed to structural disease in the neighbourhood of the valve; such may be the obvious pressure effects of aortic aneurysms and mediastinal growths and glands, and their recognition, quite apart from any question of localizing signs, can usually be definitely established by radiological examination.

(d) Treatment

Symptomatic treatment

As a general rule the treatment of pulmonary valve disease is essentially concerned with symptomatic remedies, specific therapy, either medical or surgical, not having yet been evolved for the relief of either the stenotic or the regurgitant lesions. For those cases of valvular heart disease and cardiac failure which in their terminal stages happen to be complicated by pulmonary valve affections the scheme of treatment should be planned on orthodox lines indicated by the primary condition, and, if there is evidence of malignant endocarditis, the appropriate scheme of therapy should be instituted (see p. 305).

Treatment of cause

Prophylaxis

Otherwise the treatment of pulmonary valve diseases is mainly preventive. The patient should be instructed to lead a sheltered life in keeping with his diminished circulatory reserve; he should be encouraged to take carefully regulated exercise short of fatigue and to obtain the maximum of sunshine and fresh air; he should be warned of the ill effects likely to be induced by physical strain; he should be as far

as possible protected from exposure to infection; and he should be promptly and adequately treated for any intercurrent illnesses he may contract, more particularly those of the catarrhal type.

(3)—Tricuspid Insufficiency

657.] This is the commonest valvular lesion of the right side of the heart.

(a) *Aetiology*

Relative or functional insufficiency may be (i) physiological, i.e. a *Functional* temporary event in healthy people after violent exertion; or it may be due either to (ii) hypertension in the pulmonary circuit, the sequel to left-heart failure and to valvular affections, more particularly mitral stenosis, or to obstructive lung diseases, e.g. emphysema, pneumoconiosis, and bronchiectasis; or to (iii) dilatation of the right ventricle associated with anaemia, prolonged pyrexia, wasting diseases, adhesive pericarditis, or lesions of the pulmonary valve, congenital or acquired.

Organic insufficiency may be due to: (i) rheumatic endocarditis, the *Organic* mitral valve being as a rule involved in addition to the tricuspid leaflets; (ii) malignant endocarditis secondary to focal sepsis, puerperal fever, gonorrhoea, pneumonia, or other infections; (iii) thickening and retraction of the valve cusps associated with chronic atheroma, chronic rheumatic carditis, the later stages of mitral stenosis, or congenital pulmonary stenosis (see p. 227).

(b) *Clinical Picture*

More often than not tricuspid insufficiency is functional rather than due to organic disease, and secondary to such conditions as mitral stenosis, adhesive pericarditis, and lesions of the pulmonary valve. The symptoms, although complicated by those of the primary disease, are moderately well defined. The patients complain of various degrees *Symptoms* of defective exercise-tolerance; they are breathless on exertion; their mental capacity and powers of concentration may be impaired; they may suffer from insomnia, indigestion, and symptoms of fluid retention in the subcutaneous tissues, the solid viscera, and the serous sacs.

The physical signs of an incompetent tricuspid valve indicate stasis *Physical signs* in the systemic venous circuit and various degrees of dilatation and failure of the right auricle and ventricle.

On inspection the face, as a rule, is cyanosed, and often there is a *Inspection* moderate grade of jaundice; epigastric pulsation is likely to be present and is usually especially prominent between the xiphoid cartilage and the left costal margin; the jugular vessels are engorged and, in addition to their wavy pulsation, they fill from below with the rhythmical systolic movement usually described as the ventricular or positive type of venous pulse.

Some of the above conditions are confirmed by palpation, particularly *Palpation* the epigastric pulsation; the apex impulse is ill defined and wavy in

*Percussion**X-ray examination**Auscultation*

type; there may be diffuse pulsation over the lower sternum and, by reason of the transmission of the regurgitant stream to the inferior vena cava, various degrees of expansile liver pulsation, which is recognized by placing one hand in front and the other on the right side of the chest over the lower ribs. The area of cardiac dullness is increased transversely and upwards, and radiological examination (see Plate IV, A) permits accurate assessment of the extent to which the chambers of the right heart are affected in the presence of tricuspid regurgitation; the electrocardiogram (see Fig. 53) shows curves characteristic of right ventricular preponderance. Apart from exceptional circumstances—such as severe cardiac failure and intercurrent lesions producing loud

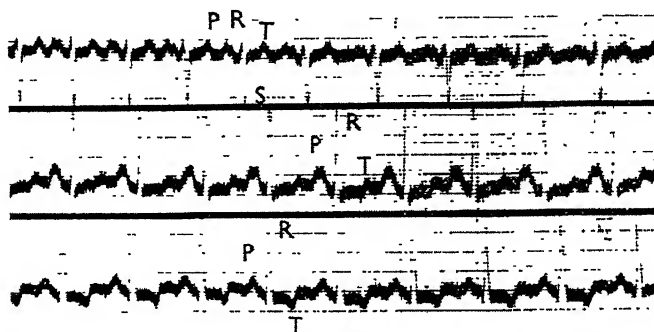


FIG. 53.—Electrocardiogram showing right ventricular preponderance and high voltage blind P-waves; case of mitral stenosis with tricuspid incompetence

Systolic murmur

murmurs, pericarditis, and exocardial sounds—tricuspid insufficiency can be recognized by the presence of a low-pitched blowing systolic murmur, which is of maximal intensity over the lower end of the sternum, may be transmitted to the right and slightly upwards but has otherwise no well recognized direction of propagation, may obscure or take the place of the first sound, and commonly is associated with a second sound of diminished intensity at the pulmonary base.

(c) *Course and Prognosis*

Development of right-heart failure

The condition progresses to dilatation and failure of the right heart and the manifestations of venous engorgement in its full form; cyanosis becomes a constant feature and is intensified by exertion; the liver and the spleen are enlarged; ascites and various degrees of stasis in the portal system develop, the latter process being responsible for the gastritis and intestinal catarrh which as a rule complicate the clinical picture; the kidneys are congested; the urine is scanty, albumin is usually present, and in two of my cases there were hyaline casts and red cells; oedema, beginning in the feet and extending to the rest of the body, is usually well marked.

The above syndrome may be relieved by treatment, and compensation

may for a time be restored; otherwise the venous stasis persists, the dropsy becomes more marked, and the symptoms of cyanotic induration and secondary fibrosis of the internal organs follow.

The prognosis of tricuspid insufficiency depends primarily upon the aetiological factors and to some extent on the associated conditions. If the condition is due to organic disease or occurs as a complication in chronic valvular heart disease, the outlook is invariably serious, but a relatively encouraging prognosis is usually justified in cases of functional insufficiency associated with dilatation of the right ventricle in such conditions as anaemia, prolonged pyrexia, wasting diseases, and adhesive pericarditis. *Prognosis*

(d) *Diagnosis*

The symptoms are by no means characteristic, but it is usually possible to establish the diagnosis of tricuspid insufficiency by physical examination. The more reliable signs include epigastric pulsation, a positive jugular pulse, a systolic murmur at the tricuspid region, a pulsating liver, and a diminished second sound over the pulmonary base, the latter development being more especially significant if, as in mitral stenosis or obstructive lung diseases, it has been previously noted to be accentuated. Further confirmatory evidence is available in the later stages of the disease, which have been described above. *Chief signs*

(e) *Treatment*

In most cases tricuspid insufficiency is a complication of another disease, e.g. chronic rheumatic carditis, chronic lung diseases, pulmonary valve lesions, or adherent pericardium, and treatment other than that indicated for the relief of the primary condition is not required for incompetence of the tricuspid valve alone.

Symptomatic therapy will suffice for the general management of patients suffering from tricuspid insufficiency; otherwise the treatment of the condition should be arranged on lines similar to those adopted in mitral stenosis (see p. 323).

(4)—Tricuspid Stenosis

(a) *Aetiology*

658.] Tricuspid stenosis is one of the rarest of valvular lesions and may be difficult to diagnose during life. Bedford Fenwick (1882) collected 70 cases verified by post-mortem examination; in all cases there was also mitral stenosis. Leudet (1888) collected 114 cases, and twenty years later Herrick (1908) brought the number up to 187. The majority of the recorded cases were in females; Newton Pitt (1909) found that the proportion of female to male cases was two to one and that the largest number occurred between the ages of twenty-one and thirty. *Incidence*

Maud E. Abbott (1927) summarized the recorded cases of congenital stenosis, a condition even rarer than congenital atresia (complete obliteration of the tricuspid orifice). Congenital tricuspid stenosis in

combination with pulmonary stenosis is less rare than congenital tricuspid stenosis alone. These lesions of the tricuspid valve may be due either to congenital malformation, in which event there is not any evidence of inflammation, or to foetal endocarditis.

(b) Clinical Picture

<i>Inspection</i>	Persistent cyanosis, distension and stasis in the cervical veins, and exaggerated pulsation, auricular in type, of the jugular vessels are characteristic of tricuspid stenosis. A systolic or a presystolic thrill may be felt in the tricuspid region; the liver is probably enlarged and in well developed cases may show definite pulsation. An increased area of dullness to the right of the sternum may be elicited, but usually percussion findings are of doubtful value as compared with those of a radiological examination, which in typical cases of tricuspid stenosis shows not only the degree of the enlargement of the right auricle (see Plate IV, B and C) but also the excessive pulsation in the dilated superior vena cava and the clear lung fields which are usually characteristic of the lesion in its compensated stages. A loud high-pitched presystolic or mid-diastolic murmur may be audible in the tricuspid region to the right or the left of the sternum near the ensiform cartilage, but more often the murmur is systolic in time, and in most cases the auscultatory signs of the tricuspid lesion tend to be entirely obscured by the more obvious murmurs which signify the presence of concomitant stenosis at the mitral orifice.
<i>Palpation</i>	
<i>Percussion</i>	
<i>X-ray examination</i>	
<i>Auscultation</i>	

(c) Course and Prognosis

The primary effect of a stenotic lesion at the tricuspid valve is to increase the load supported by the right auricle; for a variable length of time compensatory hypertrophy is adequate, but as the lesion progresses dilatation supervenes and with it the development of venous congestion, dropsy, and effusions into the serous sacs.

(d) Diagnosis

Apart from congenital defects, tricuspid stenosis is usually incidental to a severe degree of rheumatic carditis, and, although the outstanding clinical signs may be those of a co-existing lesion of the aortic or the mitral valve, there may be definite evidence of obstruction at the tricuspid orifice, e.g. persistent cyanosis, stasis and an exaggerated auricular impulse in the jugular vessels, a pulsating liver, enlargement of the right auricle, and a harsh presystolic or systolic murmur, possibly also a thrill, at the tricuspid region.

(e) Treatment

Treatment is in broad principle similar to that of mitral stenosis (see p. 323).

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X.—HEART FAILURE

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1.—DEFINITION

659.] Failure of the circulation may be due either to defective filling of the heart during diastole or to defective emptying during systole. The type due to defective diastolic filling results from capillary dilatation, and is spoken of as 'peripheral failure', whereas the term 'heart failure' is applied only to inability of the ventricles to empty themselves during systole.

2.—PHYSIOLOGY: THE CARDIAC RESERVE

Heart failure is a relative term. It implies that the heart is unable to maintain an output of blood adequate to meet the requirements of

the body. So long as the balance between supply and demand is maintained all goes well; but, as soon as the demand exceeds the supply, symptoms of cardiac insufficiency make their appearance. The reserve of the healthy heart is amply sufficient to meet all contingencies. In the trained athlete the heart is able to increase its output sixteen-fold (A. V. Hill, 1927); in patients with advanced heart failure it is unable to satisfy the requirements of the body even at rest. Between these two extremes, all intermediate degrees of cardiac efficiency are found in health and disease.

In patients with heart disease there are two factors involved in limiting the cardiac reserve: the one is anatomical and beyond the scope of medical treatment, the other is chiefly biochemical and can be influenced by suitable therapeutic measures. This can be illustrated in the form of a diagram.

In Fig. 54, (i), the column AC represents the capacity of the heart for work in a normal healthy subject, AB being the resting or basal requirement and BC the additional amount of work which can be undertaken without signs of distress, i.e. the cardiac reserve. As the result of athletic training, the 'condition' of a normal person

improves and he is able to undertake more severe exertion without discomfort. The part CD represents the additional reserve of the trained athlete. On the other hand, the man who leads a sedentary life and does not take sufficient exercise to keep himself 'fit' falls below normal, just as the athlete rises above it. These three columns represent the variations found in health, which may be termed the average (Av), the athletic (ATH), and the sedentary (SED) types.

The second diagram (Fig. 54, ii) represents the variations in the cardiac reserve in a patient with a severe heart lesion. His reserve can likewise be increased by treatment (b); but, if he neglects his health, the heart's capacity for work may fall below the basal level (c), which is higher in the cardiac than in the normal subject (see p. 371). Then, even at rest, he will have symptoms of cardiac insufficiency.

Chronic disease of the heart muscle, the heart valves, or the coronary arteries entails a reduction of the cardiac reserve proportional to the severity of the structural lesion. The resulting disability is permanent.

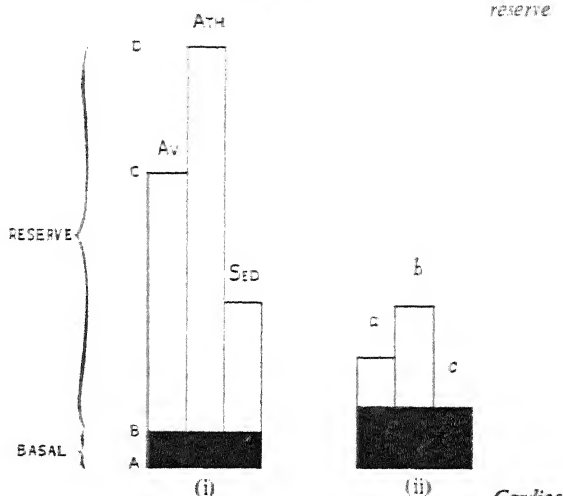


FIG. 54.—Diagram showing capacity of heart for work in (i) normal health, and (ii) cardiac disease. For explanation see text below

*Lack of
exercise*

Lack of exercise adds further to the disability by producing a biochemical change in the buffering mechanism in the muscles. This reduces their mechanical efficiency: they work less economically and, for the same output of energy, require a greater supply of oxygen than 'trained' muscles, thus increasing the demand upon the heart. The myocardium is similarly affected. This additional disability may be partially eliminated by appropriate treatment.

Neuroses

Lastly, in all cases of heart disease, the element of neurosis plays a part, and treatment is never complete unless the psychological aspect is taken into consideration.

3.—CLINICAL TYPES

In patients with heart disease, the tolerance for exercise is usually limited either by dyspnoea or by pain. It is rare for these two symptoms to be equally prominent in the same case. One or other usually dominates the picture, and, since dyspnoea is generally the precursor of venous engorgement, whereas anginal pain is believed to be due to myocardial ischaemia, it is convenient to speak of two types of heart failure, 'congestive' and 'ischaemic'.

(1)—Congestive Heart Failure

(a) *Aetiology*

*Association
with
auricular
fibrillation*

Congestive heart failure may be due to various causes; of these by far the commonest is auricular fibrillation. In untreated auricular fibrillation the heart-rate is usually very rapid, and its rhythm extremely irregular. Hence the ventricles are working overtime; they get insufficient rest, become fatigued, and sooner or later dilate. Many heart-beats follow each other in rapid succession. Consequently the ventricles often contract before they have had time to fill with blood and many beats are unproductive, the cardiac output being so small that the pulse wave fails to reach the periphery. The difference between the heart-rate as counted with a stethoscope at the apex and the pulse-rate at the wrist is known as the 'pulse deficit' and indicates the number of unproductive beats. In spite of the fact that the ventricles may be beating at twice their normal rate, their output per minute is reduced. Hence the blood-flow in the coronary arteries is diminished, and the overworked ventricles are undernourished. It is not paralysis of the auricles, but ventricular tachycardia, that is to blame for the heart failure which so frequently follows auricular fibrillation.

'Pulse deficit'

*Congestive
heart failure
with normal
rhythm*

Congestive heart failure with normal rhythm is a much less common condition. It is most apt to occur in old-standing cases of high blood-pressure and cardio-aortic syphilis, or as a circulatory complication of chronic pulmonary disease, such as emphysema.

(b) *Dyspnoea*

Under normal atmospheric conditions, healthy young people in good physical training do not suffer from dyspnoea, except during and

immediately after violent exertion, because the depth of respiration (i.e. the tidal air) can be increased four-fold without distress. The actual process of muscular contraction is entirely anaerobic, and depends on the conversion of glycogen into lactic acid with the liberation of energy. This is followed by what is called the 'recovery phase', during which the lactic acid is disposed of, partly by oxidation to carbon dioxide and partly by reconversion into glycogen. During exercise the contraction and recovery processes take place concurrently, and, so long as the removal of lactic acid keeps pace with its production, an equilibrium is established and exercise can proceed. As soon, however, as the blood-supply becomes inadequate to provide for oxidation of the lactic acid, this substance begins to accumulate in the tissues, and, as A. V. Hill and his co-workers have expressed it, the body 'goes into debt' for oxygen. The panting which follows the cessation of exercise is necessary to pay off this debt by supplying sufficient oxygen to provide for the removal of the lactic acid which has accumulated in the body during exercise.

*Physiology
of muscular
contraction*

One of the most important factors in maintaining a supply of oxygen to the muscles adequate to ensure the removal of lactic acid is the functional efficiency of the heart. The heart has to provide for the transportation of oxygen; in congestive heart failure transportation breaks down, because the ventricles are no longer capable of maintaining a sufficient output of blood to meet the oxygen requirements of the tissues. The circulation rate is slowed, and, in spite of utilizing a larger percentage of oxygen than normal from each unit volume of blood as it passes through the capillaries, the total volume of oxygen available is inadequate.

*Causes of
dyspnoea*

*Slowing of
circulation*

In addition to the slow circulation rate, other factors play a part in the production of cardiac dyspnoea. Owing to venous engorgement the elasticity of the lungs is impaired, their movements are rendered more difficult, and the vital capacity is reduced. Similarly oedema of the lungs interferes with the gaseous exchange, and in some cases this defect is further enhanced by an element of bronchiolar spasm.

*Changes in
the lungs*

Lastly, as Peabody and his associates showed, the basal metabolism (i.e. the minimal oxygen requirement of the body at rest) is raised in patients with heart disease. Hence the cardiac patient starts at a disadvantage, for his resting basal requirement is greater than that of the healthy person. On exertion, owing to his slow circulation rate, the demand of his muscles for oxygen quickly outstrips the supply; his diminished vital capacity entails relatively shallow breathing, and the rate of respiration has in consequence to be unduly rapid. The result of the interaction of all these adverse conditions, as shown in Fig. 55, is that dyspnoea is very easily produced in patients suffering from heart disease.

*Increase
in basal
metabolism*

A second result of the sluggish circulation is excessive de-oxygenation of the blood. The amount of reduced haemoglobin in the capillary blood is increased, and consequently the patient becomes cyanosed. The

Cyanosis

associated cyanosis assists in the diagnosis between cardiac dyspnoea and dyspnoea due to purely nervous or other causes, such as uraemia and ketosis.

(c) Venous Engorgement

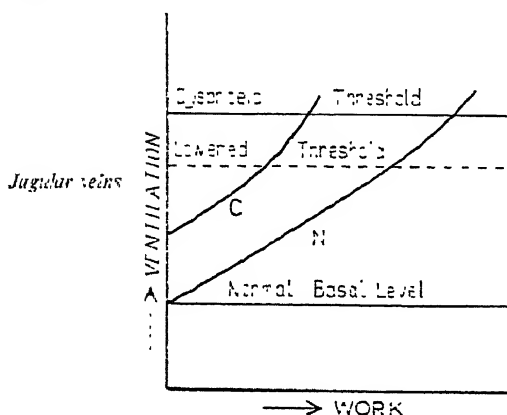
When the cardiac reserve is still further reduced, the ventricles are unable to dispose of the blood as quickly as they receive it—the inflow exceeds the output—and the venous pressure rises. The patient is then said to be suffering from 'congestive heart failure'.

The presence of venous engorgement can most easily be recognized

in the organs in close proximity to the heart, namely, the liver and the lungs. The liver enlarges, moist sounds are heard at the pulmonary bases, and the veins in the neck stand out like knotted cords.

The degree of engorgement of the jugular veins affords a rough measure of the increase in venous pressure. When it is only slightly raised, the veins collapse if the patient sits up; but, when the venous pressure is considerably above normal, the veins stand out even in the erect posture. Venous engorgement also affects other organs, such as the stomach and the kidneys, but there its presence can only be deduced from indirect evidence, such as nausea, dyspeptic symptoms, oliguria, and

Liver and
lungs.



Stomach and
kidney

FIG. 55.—Diagram showing increase of respiratory activity with work in (N) normal and (C) cardiac subjects and the lowered threshold for dyspnoea when the perceptive nervous mechanism is hypersensitive (*Lancet*, 1927)

Anasarca

albuminuria. Lastly, anasarca develops, and fluid accumulates in the peritoneal and pleural cavities, giving rise to ascites and hydrothorax.

(d) Failure of the Left Ventricle

On the Continent and more recently in America, the conception of independent failure of one or other ventricle has attracted considerable attention. When the causes of heart failure are considered, it is obvious that in different types of heart disease the burden falls unequally on the two ventricles. In vascular hypertension, for example, the left ventricle has to bear the strain, and not until it has given way does the right ventricle become embarrassed. Conversely, in rheumatic heart disease with mitral stenosis, or in emphysema, the burden falls on the right ventricle.

The signs of congestive heart failure referred to above, namely, venous engorgement in the systemic circuit, as shown by enlargement of the liver, oedema, and engorgement of the veins of the neck, are attributable to inability of the right ventricle to maintain an output equal to its

intake. Conversely, engorgement in the pulmonary circuit indicates failure of the left ventricle. Pulmonary congestion is easily recognized on radiographic examination and is manifested clinically by moist sounds at the bases of the lungs.

In most cases of heart failure both ventricles are involved to a greater or lesser extent; but, when the left ventricle alone is at fault, there may be intense congestion in the pulmonary circuit without any oedema or engorgement of the systemic veins. Left ventricular failure is most liable to develop in patients with high blood-pressure, cardio-aortic syphilis, or coronary atherosclerosis, and certain signs associated with it merit special consideration. They are paroxysmal dyspnoea, pre-systolic gallop rhythm, and pulsus alternans.

Signs of left ventricular failure

The underlying cause of paroxysmal dyspnoea, or as it is commonly called 'cardiac asthma', is acute hypertension in the pulmonary circuit. The stagnation of the blood in the lungs leads to an increase in the vascular bed. This gives rise to what has been termed 'secondary emphysema' with a reduction which may amount to 50 per cent in the vital capacity. The nocturnal incidence of the attacks probably depends on the horizontal posture.

Aetiology

Secondary emphysema

Paroxysmal dyspnoea differs from the more common dyspnoea of effort in that it is not brought on by exertion but occurs at rest. It often wakes the patient from sleep in the early hours of the morning, and I have known patients beg their nurse not to allow them to go to sleep, so frightened were they of the attack which would ensue on waking. It is perhaps the mental anguish even more than the physical discomfort which terrifies the patient, and which is so well portrayed in Allbutt's graphic description of a severe attack: 'The patient, seized and throttled before he could cry out, sprang up livid to wrestle with death. The desperate conflict made the fell enemy almost visible to us. Now this way, now that, springing up in bed to fight from the edge of it, to sink back in utter exhaustion, but only to rise again panting, with the sweat streaming from him, desperately to renew the battle, the scene was almost as distressing to the bystanders as to the victim.'

Paroxysmal dyspnoea

The attack may closely simulate bronchial asthma, and the differential diagnosis may rest on the presence of other signs of left-heart failure and of grave cardiac disease. A slight attack may pass off in a few minutes, but a severe one will last for half an hour or more, and may develop into acute pulmonary oedema.

Diagnosis from bronchial asthma

Other types of dyspnoea which must be distinguished from cardiac asthma are the air-hunger of uraemia and diabetes mellitus. The first is due to the inability of the damaged kidney to regulate the acid-base equilibrium of the body, and the latter to alteration in the pH of the blood owing to the presence of ketone bodies. Renal and diabetic asthma may develop by day. They are more persistent and less paroxysmal in character than cardiac asthma. The differential diagnosis usually presents little difficulty, in view of the presence of collateral evidence of nephritis or of diabetes mellitus.

From uraemia and diabetic asthma

Prognosis

Cardiac asthma carries a grave significance in prognosis; forty-two out of eighty-seven patients in the series reported by Weiss and Robb died within twelve months of the appearance of this symptom.

Treatment

Adrenaline and other asthmatic remedies bring little benefit, but morphine acts as a specific. Twenty or thirty minims of nepenthe (a proprietary preparation of opium containing 0.84 per cent of morphine in alcoholic medium) at bedtime will often ward off attacks.

Presystolic gallop rhythm

Presystolic gallop rhythm has been aptly termed 'the cry of the heart for help'. It is a sign that the last reserves have been called up and that the left ventricle is struggling against desperate odds. Presystolic gallop rhythm can usually be distinguished from other types of triple rhythm

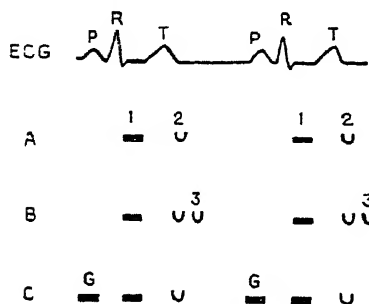


FIG. 56.—Diagram showing time relation of (3) accentuated third heart sound and (G) gallop sound to (1) first and (2) second normal heart sounds.

E.C.G., electrocardiogram. A, normal heart sounds. B, protodiastolic gallop. C, presystolic gallop (*Lancet*, 1936)

Prognosis

only were alive eighteen months after they first came under observation (Bramwell, 1935, b).

Pulsus alternans

In pulsus alternans, a sphygmographic tracing shows strong and weak beats alternating with one another. The difference in the strength of the beats is insufficient to be appreciated by the finger, but can be easily recognized with the aid of the sphygmomanometer. When the pressure in the armlet is only slightly below systolic, the weaker beats fail to come through and the pulse-rate at the wrist is only half the heart-rate. As the pressure in the armlet is allowed to fall, a point is reached at which the pulse-rate suddenly rises to double its previous value.

Diagnosis from extrasystole

Pulsus alternans must be distinguished from bigeminal heart action in which a weak beat due to an extrasystole follows each normal cycle. In this case, the weak beat is premature, and the premature sounds can be heard on auscultation. In pulsus alternans, on the other hand, the heart sounds are normal in rhythm and the large and small beats are evenly spaced.

Significance

When the heart-rate is unduly rapid, as in paroxysmal tachycardia or in auricular flutter, pulsus alternans is common and is of no significance.

When, however, it is associated with a normal heart-rate, it is a sign of left ventricular defeat.

(2)—Ischaemic Heart Failure

When the output of the heart is inadequate to meet the requirements of the body, lactic acid accumulates in the muscles, the hydrogen-ion concentration of the blood rises, and the patient becomes dyspnoeic. When, on the other hand, it is only an isolated group of muscles that is deprived of its blood supply, the presenting symptom is not dyspnoea but pain.

This is exemplified by intermittent claudication, resulting from thrombo-angiitis obliterans. It can also be produced experimentally by active movements of a limb, when the blood supply is artificially cut off by a tourniquet (McWilliam and Webster).

That anginal pain is due to myocardial ischaemia is suggested by the fact that the various conditions known to be intimately associated with angina are such as would be likely to lead to a shortage in the supply of oxygen to the heart muscle. The recognition of coronary occlusion as a distinct clinical syndrome has thrown considerable light on this aspect of the problem.

In considering the work done by the heart, it is not surprising that even the slightest interference with the coronary circulation limits the cardiac reserve. A. V. Hill (1927) showed that in an athlete during severe exertion the heart muscle alone may consume as much oxygen as does the whole body at rest. By collecting and analysing the expired air, Hill calculated the amount of oxygen consumed by the body during exercise, and from these data estimated the output of the heart per minute. The calculation is as follows:

*Cardiac
output at rest
and during
exercise*

A litre of blood will carry about 200 c.c. of oxygen; by analysis of the arterial and venous blood it can be shown that, when the heart is at rest, the tissues extract about 35 per cent (70 c.c. per litre) of the oxygen passing through them. Since, at rest, the oxygen consumption of the body is about 250 c.c. per minute, the output of the left ventricle must be about 4 litres per minute. During severe physical exertion, such as rowing, the oxygen consumption may actually amount to over 4 litres per minute, i.e. sixteen times the resting requirement. Under such conditions, the dilatation of the capillary field will no doubt allow of a greatly increased coefficient of utilization of oxygen (say 70 instead of the normal 35 per cent). On the other hand, the circulation through the lungs is so rapid that the arterial blood has not time to get fully saturated with oxygen. Assuming that the arterial saturation is 18.5 instead of the normal 20 volumes per cent, each litre of blood will give up $185 \times \frac{70}{100}$ (= 130) c.c. of oxygen, to the tissues.

Hence an oxygen requirement of 4.4 litres per minute means a circulation rate of $\frac{4.4}{0.13}$ (= 34) instead of the normal 4 litres per minute. Considering the right ventricle as well as the left, the total cardiac output reaches the enormous figure of 68 litres per minute.

*Work
performed
by heart*

We can now go a step farther. The product of this output and of the blood-pressure gives the work performed by the heart. Allowing a 20 per cent efficiency, it is possible to make a rough computation of the amount of oxygen which the heart muscle would require to perform this amount of work. This is found to be equivalent to the amount consumed by the whole body when at rest.

*Causes of
myocardial
ischaemia*

Myocardial ischaemia may be due to various causes. Of these the most obvious are narrowing of the coronary arteries by atherosclerosis or obstruction of the mouths of these vessels by syphilitic aortitis. That coronary spasm may play a similar part is suggested by the beneficial therapeutic effect of vasodilator drugs. The low diastolic pressure will account for angina in patients with rheumatic aortic incompetence, for Anrep has shown that the coronary blood-flow depends chiefly on the aortic diastolic pressure. A reduction in the coronary blood-flow can be demonstrated in dogs in which aortic incompetence has been experimentally produced (Smith, Miller, and Graber).

*Cause of
death*

The liability to sudden death in angina pectoris can be explained on the same hypothesis. McWilliam (1889) showed that in animal experiments a poor blood-supply rendered the ventricles especially liable to fibrillate. As a deduction from his experiments, he suggested that ventricular fibrillation was probably the cause of sudden death in heart disease. Lewis corroborated this hypothesis by showing that ligation of one coronary artery might cause death through ventricular fibrillation, and this observation has since been confirmed by other workers.

4.—PROGNOSIS

The aim in the treatment of heart disease is to enable the heart to balance its budget, and prognosis depends essentially on its ability to do so.

On the debit side of the account the principal items are as follows: (1) The structural lesions; these determine the basal disability. (2) The functional derangements of the cardiac mechanism; these are to a greater or lesser extent amenable to appropriate therapeutic measures, but the response to treatment varies considerably in different cases. (3) The aetiology of the condition. (4) The stage at which efficient treatment is instituted.

On the credit side we have to assess the demands which the heart will be called upon to meet. The social and economic status of the patient, the nature of his work, his temperament, his ability and willingness to co-operate with his doctor and to reduce his commitments, all have to be taken into account. Without amplifying in detail these various points, a few examples will serve as illustrations.

*Enlargement
of heart*

Enlargement of the heart as a whole, or of any of its chambers, implies that the affected chamber is finding difficulty in doing its work. Enlarge-

ment may be due either to hypertrophy or to dilatation, and it is rarely possible to determine with accuracy which of these changes predominates. Hypertrophy is a compensatory mechanism: dilatation may also be compensatory as in the case of aortic regurgitation, but more commonly it is a sign of unfavourable significance. Broadly speaking, other things being equal, the greater the enlargement the greater is the heart's embarrassment, and the more unfavourable is the prognosis.

The close connexion between heart failure and auricular fibrillation was referred to on page 370. There is, however, no disorder of the cardiac mechanism more amenable to treatment. Consequently in cases of heart failure hitherto untreated, or inadequately treated, a better response may be expected with fibrillation than with normal rhythm. *Auricular fibrillation*

A prolonged paroxysm of tachycardia may lead to heart failure. Here again the prognosis is favourable, on account of the natural tendency for the paroxysm to stop spontaneously. *Paroxysmal tachycardia*

In certain types of heart disease, such as cardio-aortic syphilis, heart failure is a terminal event, and the prognosis is correspondingly unfavourable. This may be contrasted with heart failure resulting from some intercurrent infection such as acute bronchitis: when the bronchitis clears up, the heart failure promptly subsides. *Other types of heart failure*

In connexion with aetiology consideration must be given to the influence of age, but this can be discussed in very general terms only. Old people tolerate heart failure badly. They are more liable to develop hypostatic congestion, especially when they have to be confined to bed. Each of the different types of heart disease has its own natural history. Women with chronic rheumatic heart lesions often break down at the menopause, and many die before the age of fifty. *Age*

The family history must also be taken into account. I know of three families in which three or more members enjoyed comparatively good health up to the age of fifty and died of coronary disease in the course of the next seven years. *Family history*

Finally, the importance of early diagnosis and treatment must be emphasized. During the past eight years I have followed through the later months of pregnancy, through labour and the puerperium, a series of more than 400 patients with heart disease (1935, a). Many of these developed heart failure while under observation, but almost without exception they have responded well to treatment. A few, however, had not been under our antenatal supervision, but were admitted to hospital as 'urgencies' with advanced congestive heart failure. The mortality in this group amounted to more than 50 per cent. Had these cases been seen when the signs of heart failure first appeared, I am convinced that some lives could have been saved.

In acute heart failure it is often quite impossible to foretell the outcome, in view of the numerous complications which may arise. For example, a man with coronary occlusion may die in the attack from ventricular fibrillation. If he survives, unless the affected artery is small, his condition may be critical for forty-eight hours or more owing to *Difficulty of prognosis*

shock. When that danger is past, he is left with an infarct in the heart wall, which may lead to rupture of the ventricle. Even when the infarct has healed, the heart may prove unequal to its work, and death from progressive heart failure may result six months or more after the attack. Finally, every patient who recovers is a likely candidate for another attack, which may prove fatal. It has been truly said that the only certainty in such cases is that a definite prognosis will almost certainly be wrong.

5.—TREATMENT

(1)—General

The main objective in the treatment of both the congestive and the ischaemic types of heart failure is to enable the heart to balance its budget. To do so, every effort must be made to reduce the liabilities which it is called upon to meet, and at the same time to increase its assets.

Rest and exercise

Since physical exertion makes the greatest demand upon the heart, rest is the most important consideration in the treatment of heart failure. In incipient heart failure slight curtailment of the normal daily routine may suffice; but in advanced cases, when the patient is oedematous or is subject to anginal attacks on slight exertion, complete rest for a period of several weeks may be necessary to enable the exhausted heart to build up a reserve. In these circumstances the patient must be confined to bed and be attended by competent nurses who will feed him, wash him, and even lift him when he wishes to change his position. He must not be allowed to make any physical effort, or even to attempt to assist his nurses in moving him. He must use a bed-pan. Dyspnoeic patients are more comfortable sitting up than lying flat. Some, especially the obese, find it easier to sleep in a chair, leaning forward with the forearms supported by a table and the head resting on the forearms. Whatever position the patient finds most comfortable should be adopted, and, if in bed, the feet and knees should be supported to prevent him from slipping down. Skilled nursing is one of the most important considerations in the treatment of heart failure, for it is the only means of ensuring complete bodily rest.

Convalescence During convalescence massage to the limbs and back is helpful in restoring tone to muscles which have become flabby through disuse. This should be followed by resistance exercises and finally by graduated walking exercise.

Prevention of recurrences When convalescence is complete, the future still remains to be considered, and steps must be taken to prevent a recurrence. The patient must be warned against over-exertion on the one hand and insufficient exercise on the other. Whereas the former may precipitate another attack, the latter will add to the impairment of his cardiac reserve. The advice which I give to patients with chronic heart disease may be summarized by saying that they must observe moderation in all things,

taking regular exercise within the limits of their tolerance, but never making any sudden effort which entails exerting their full strength, or which produces dyspnoea or precordial discomfort. For example, they must never run for a train, struggle against the wind, or attempt to start their motor car by hand. They must stop eating before they are satisfied, and sit quietly in a chair for half an hour after meals.

Next in importance to physical rest is peace of mind, for a state of *Anxiety* mental anxiety is incompatible with physical relaxation. Here psychological considerations predominate, and call for tact and cheerfulness on the part of both nurse and doctor.

An adequate period of sleep must be secured at all costs. When lack of sleep is due to pain, morphine may be necessary, but often one of the milder hypnotics, such as 5 grains of allobarbitone (dial) with 5 grains of aspirin, will suffice. Paraldehyde is a safe hypnotic in these cases, but it must be given in full doses (i.e. not less than 2 fluid drachms). A 'night-cap' of whisky with hot water and lemon is often helpful. *Hypnotics*

When the patient is acutely ill, fluid only will be tolerated, and this *Diet* is best given in the form of peptonized milk, one pint in the twenty-four hours being sufficient. If milk alone is not tolerated, it may be diluted with an equal quantity of lime-water or aerated distilled water, and three or four drops of weak tincture of iodine may be added to the mixture. Glucose given with insulin has been recommended in acute heart failure but opinion is divided regarding the efficacy of this line of treatment.

Patients with persistent vomiting can sometimes retain iced champagne; but it may be impracticable to feed them by the mouth, and rectal feeding may have to be resorted to. A small enema, consisting of an ounce of glucose in a pint of physiological saline, given four-hourly, is preferable to the more complex formulae sometimes prescribed. Obstinate flatulent distension of the stomach can frequently be overcome by this means when all other methods of treatment have failed. *Rectal feeding*

When the patient is again able to take solid food, a dry diet is best, thirst being quenched by drinking between, instead of with, meals (i.e. half an hour before, or one hour after, a meal). The meals should be small in order to avoid over-distension of the stomach, and given at frequent intervals. During the day the patient should never go longer than three hours without food, though in the acute stage of the illness the total heat value of the diet need not exceed 1,000 Calories.

Flatulence is often troublesome; it may be relieved by a carminative after meals, in the form of a couple of soda mint tablets or of the following mixture. *Treatment of flatulence*

Menthol	-	-	-	-	-	$\frac{1}{4}$ grain
Aromatic spirit of ammonia	-	-	-	-	-	30 minims
Compound tincture of cardamom	-	-	-	-	-	30 minims

For patients accustomed to take alcohol, crème de menthe may be

*Alcohol, tea,
and coffee*

prescribed in place of the usual carminatives. Strong tea should be prohibited, even during convalescence, but weak China tea and milky coffee are permissible.

*Rest after
meals*

Flatulent distension due to dietetic indiscretion may precipitate an attack of acute heart failure, and even slight exertion after a meal will evoke symptoms of distress in a patient whose cardiac reserve is limited. In the early stages of angina of effort, it is by no means uncommon for the patient to complain of pain when walking to the station in the morning, and to be free from pain throughout the remainder of the day. The reason is obvious. He likes to lie in bed until the last possible moment, bolts his breakfast, and dashes off to catch his train. It is a sound rule for the patient with incipient heart failure, either of the congestive or of the ischaemic type, to sit quietly in a chair for at least twenty minutes after meals.

Obesity imposes an unnecessary burden on the damaged heart. Moreover it establishes a vicious circle; for by diminishing the cardiac reserve it limits exercise, and lack of exercise tends to increase obesity. To break this circle, a diet low in fats and carbohydrates should be prescribed together with massage and carefully graduated exercise.

(2)—The Nervous Factor

In the treatment of all cases of heart failure, but especially in those of the ischaemic type, the nervous aspect calls for careful consideration. The typical anginal subject is by no means a neurotic; but some patients are more highly strung than others, and the nervous pattern of the individual is largely instrumental in determining the clinical picture, which it may modify in various ways. In the first place, the threshold of sensitivity to pain varies in different people. Other things being equal, the limitations imposed on the patient's activities are much greater in the hyper- than in the hypo-sensitive subject. Secondly, in the irritable 'nervy' type of individual, an anginal attack may be precipitated by a relatively trivial emotional stimulus, since the detonating mechanism which fires off an attack lies dangerously near the surface. Minor annoyances will, in him, suffice to produce an emotional storm adequate to provoke a seizure; whereas, in the calm placid person, a much more massive stimulus is required to bring on an attack. Thirdly, there is the element of anxiety, for angina is proverbially associated with sudden death.

*Cerebral
depressants*

Much can be done to combat the nervous factor and thereby to reduce to a minimum the aggravation of the disease for which it is responsible. Bromides, phenobarbitone (luminal), and other cerebral depressants will render the patient less liable to attacks, and will make the attacks less distressing when they do occur. Evans and Hoyle (1933 and 1934) have shown that, in angina pectoris, when drugs are given in a routine manner, the cerebral depressants are the only group which reduce the frequency of attacks. The anxiety factor can only be treated effectively by a sympathetic and understanding medical attendant, who can

picture the outlook from the patient's point of view and appreciate his difficulties.

(3)—Drugs

The specific treatment of the different disorders of the cardiac mechanism which are intimately associated with heart failure has been fully described in the articles dealing with these subjects.

The value of digitalis in the treatment of auricular fibrillation is now *Digitalis* universally recognized. That this drug can produce benefit in cases of heart failure with normal rhythm is more difficult to prove; but many cardiologists of repute believe that it can, especially in cases of left ventricular failure with gallop rhythm and pulsus alternans.

The work of Evans and Hoyle has clarified the position with regard *Nitrites* to the use of nitrites in angina pectoris, and has shown that these drugs are useless when given in a routine manner but of great value in aborting or preventing attacks.

In the treatment of congestive heart failure with oedema, the mercurial *Mercurial diuretics* diuretics, such as injection of mersalyl (salyrgan), have added much to the therapeutic possibilities.

The position as regards cardiac stimulants is still unsatisfactory. *Cardiac stimulants* From clinical evidence drugs such as cardiazol and coramine are of undoubted value, though experiments on animals have so far failed to elucidate their mode of action.

Reference has already been made to the value of the opiates in cardiac *Opiates* asthma and acute pulmonary oedema. Cardiac patients tolerate opiates well, and the fear of using them in patients with heart failure is quite unjustified.

When heart failure is secondary to chronic pulmonary disease such *Oxygen* as emphysema, oxygen is useful, for in these cases the nutrition of the myocardium suffers from the general anoxaemia due to defective oxygenation of the blood in the lungs. Similar benefit cannot be expected when dyspnoea and cyanosis are due either to a sluggish circulation or to direct transference of the blood from the right to the left side of the heart, as occurs in some forms of congenital heart disease. In these cases the blood becomes fully saturated with oxygen in passing through the lungs, and the fault lies not in the lungs but elsewhere.

The aim of oxygen therapy is to increase the tension of oxygen in the alveolar air. It has been proved experimentally that this cannot be achieved by the old 'open' method with a funnel suspended in proximity to the patient's face. If an oxygen tent is not available, the simplest effective method of giving oxygen is to deliver it through a small rubber catheter pushed well back into the nasopharynx, and held in position by a piece of strapping attached to the upper lip. The oxygen should be bubbled through water, as the dry gas is irritating. A tablespoonful of brandy may be added to the water, so that some of the alcohol vapour is carried over with the oxygen. Incidentally the water-bottle

Method of administering oxygen

serves as a gauge to measure the amount of oxygen the patient is getting. The gas should pass through the water at a rate of at least five bubbles per second.

Venesection

Blood-letting to the extent of 10 to 20 ounces may prove a life-saving measure in acute heart failure. The special indications for employing this treatment are venous engorgement with cyanosis and acute pulmonary oedema.

(4)—Surgical Measures

Thyroid-ectomy

Certain surgical measures which have been employed in the treatment of heart failure merit consideration, though they must still be regarded as being in the experimental stage. Complete thyroidectomy by lowering the basal metabolism reduces the heart's liabilities, and might therefore be indicated on theoretical grounds. In congestive heart failure the results of this operation have not come up to expectation, but in angina they have been more promising. Operations such as sympathectomy serve to relieve pain, but whether these procedures are justified appears doubtful, for pain in angina is a danger signal which warns the patient that he is overtaxing his heart; if therefore the pain is relieved without eradicating the cause of the disease, an important safeguard may be removed.

Sympath-ectomy

(5)—Summary

In Fig. 57 I have attempted to summarize diagrammatically the therapeutic possibilities in the treatment of heart failure of the ischaemic type. A similar diagram could be devised for the congestive type.

In the normal healthy subject (I), the cardiac reserve (A-E) far exceeds the basal resting requirements of the body (E-F). In the patient with angina (II), on the other hand, the cardiac reserve (C-D) is greatly reduced. The reduction is in part attributable to impaired efficiency of the heart (A-C). This depends on various factors, of which the most important is insufficiency of the coronary circulation (A-B). Structural changes in the coronary arteries and in the myocardium are permanent and therefore beyond the scope of therapeutic measures. But, as has been pointed out above, the nervous factor is of great importance in determining not only the sensitivity to pain but also the liability to attacks. This can be, in part at least, controlled by cerebral depressants. Similarly, toxic factors affecting the myocardium, such as tobacco and focal sepsis, may be eliminated. By these means efficiency of the damaged heart can be increased from D-C to D-C'. It may be hoped, by suitable treatment, to lighten to some extent the load imposed upon the heart by such factors as obesity and high blood-pressure, thereby increasing the cardiac reserve from C-D to C-D'. That marks the limit of possible therapeutic achievement. When it has been attained, the patient must be content to adapt his mode of life to his reduced exercise tolerance C'-D'.

Briefly, the aim in treatment is to enable the heart to balance its budget by increasing its intrinsic assets, by reducing its extraneous

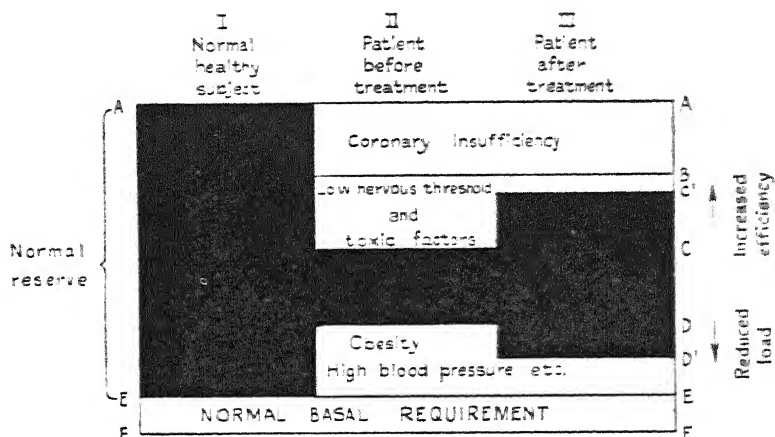


FIG. 57.—Diagram showing cardiac reserve (dark area) in (I) normal subject, (II) patient with angina before treatment, and (III) same patient after treatment. Various factors limiting cardiac reserve in anginal patient are shown in II and III. Limitation is due partly (D-E) to increased basal requirement and increased cardiac load, and partly (A-C) to impaired myocardial efficiency (*Proceedings of the Royal Society of Medicine*, 1935)

liabilities, and, finally, by adapting the patient's mode of life to the capacity of his damaged heart.

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HEAT CRAMP

See CRAMP, Vol. III, p. 452

HEAT, RADIANT

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Reference may also be made to the following titles:

ACTINOTHERAPY

DIATHERMY

1.-DEFINITION

660.] The term radiant heat therapy has long been used for a form of treatment in which the body is exposed to rays emitted from the incandescent filament of an electric lamp or a coil of wire heated to redness. Heat rays are emitted from both sources. The first yields also the rays of the visible spectrum from red to violet; and the second also visible red rays. Although visible rays, like heat rays, are thermogenetic in action, their energy is insufficient to produce appreciable heat in the body. Consequently the therapeutic effects that follow exposure to the sources just mentioned are due almost entirely to the heat rays. *Radiant heat therapy*

At the present time increasing use is being made of objects heated just below redness as a source of heat rays. They do not emit rays of other kinds. Since their introduction it has become the custom to use

*Infra-red
rays*

the name infra-red for the heat rays emitted not only from these non-luminous sources but also from those first mentioned. The name infra-red denotes the position of the heat rays in the spectrum in relation to that occupied by the visible rays. It also serves to distinguish them from other rays, such as the short electro-magnetic or Hertzian, which also have the power to heat the body. In the remaining part of the present article the expression infra-red will be used in place of radiant heat, not only for the rays but also for the generators and the treatment conducted by their means.

The name infra-red might create the impression that a new form of treatment had been introduced, but the treatment is one of extreme antiquity. What actually is relatively new is work on the penetrating power of infra-red rays, improvement in the design of filament lamps for producing them, and the introduction of special generators that yield infra-red rays only.

2.—WAVE-LENGTHS

*Wave-length
units*

In physics the length of a wave is measured in Ångstrom units. An Ångstrom unit, denoted by the symbol Å, is a ten-millionth part of a

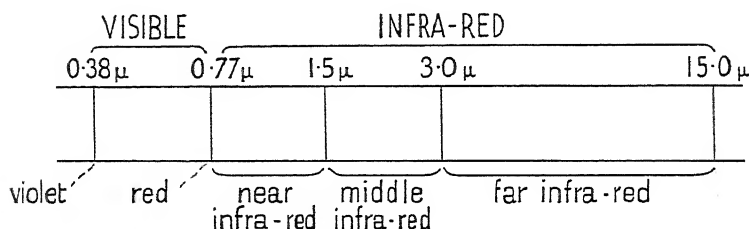


FIG. 58.—Visible and infra-red spectrum

millimetre. A micron, denoted by the symbol μ , is a thousandth part of a millimetre. Therefore 1μ equals $10,000 \text{ Å}$. As medical workers are more familiar with microns than with Ångstrom units, the wave-lengths of infra-red and visible rays will be given in terms of microns.

Infra-red rays are those of which the wave-length is longer than that of visible red rays. The wave-length of visible red rays is 0.77μ . The infra-red rays that are derived from heated objects and are used for therapeutic purposes have wave-lengths that range from 0.8μ to about 15μ . The positions occupied by visible rays (from red to violet) and by infra-red rays of certain wave-lengths are shown in a schematic representation of a spectrum (see Fig. 58). The infra-red portion of the spectrum is subdivided into three regions. The region nearest to the visible portion—the so-called near region—is occupied by rays of which the maximum wave-length is 1.5μ . As this wave-length is approximately double that of the visible red rays, the near region constitutes one octave of the spectrum. Similarly the visible rays, in the region red to violet, comprise another octave. A second, or middle, region of

*Subdivisions
of infra-red
portion of
spectrum*

the infra-red spectrum is occupied by rays of wave-lengths between 1.5μ and 3μ and comprises another octave. The third, or far, region is the remaining portion of the infra-red spectrum: it is comprised of rays of wave-lengths between 3μ and about 15μ .

The reason for subdividing the infra-red portion of the spectrum in the manner shown in Fig. 58 is that the rays belonging to the near region have a much greater penetrating power than those which belong to the far region. This subject is considered on page 391. Moreover, different types of generator do not yield the same proportion of rays of all wave-lengths.

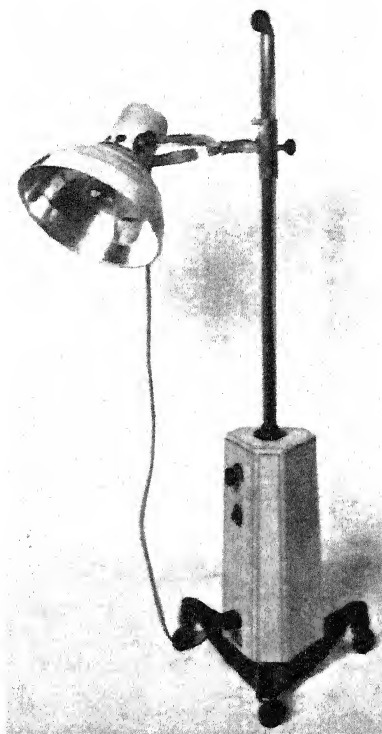
The rays belonging to the near region are sometimes called rays of short wave-length, and those that belong to the far region are sometimes called rays of long wave-length. These expressions are colloquially convenient, but it will be realized that the words 'short' and 'long' are used in a relative sense. When they are used it is necessary to add infra-red rays, because the term short waves is used in connexion with short Hertzian waves, which are at least twenty-four million times longer than the shortest infra-red rays.

3.—GENERATORS

(1)—Types

There are three main types of infra-red ray generators: (i) those in which the source of the rays is the incandescent filament of an electric lamp; (ii) those in which the rays are derived from the red-hot coils of a generator that resembles the domestic electric radiator; (iii) those in which the current heats a metal ribbon and the rays are emitted from the surface of a cylindrical or rectangular holder in which the ribbon is embedded.

(i) A widely used generator of the incandescent filament type is that known as the Sollux (see Fig. 59). It contains a single electric lamp. Within the bulb is a tungsten filament in an atmosphere of nitrogen. The lamp is mounted in front of an aluminium reflector. The maximum electrical energy needed for heating the filament to incandescence is 1,000 watts. Thus if the main voltage is 200 a current of 5 amperes will



*The terms
'short' and
'long'
wave-length*

*Three main
types*

FIG. 59.—The Sollux lamp

Type 1

be required. When this amount of energy is used, there is a uniform distribution of heat over a circular area about 5 feet in diameter at a distance of 4 feet from the bulb. The Sollux lamp can therefore be used for general treatment. When local treatment is required, a conical hood is made for attachment to the reflector for the purpose of restricting the rays to small areas of the skin. The output can be reduced, when desired, by diminishing the current. For this purpose the variable resistance (rheostat) mounted on the pedestal is used. Sollux generators are also constructed with smaller bulbs. These are used for local treatment only.

The so-called radiant-heat generators contain a number of small filament lamps mounted in a cabinet. These lamps yield a larger output

of visible than of infra-red rays. They are less efficient for therapeutic purposes than those of the modern type which are specially designed for infra-red ray treatment.

(ii) Generators that contain coils of wire heated to redness do not yield a full range either of visible or of infra-red rays. For this reason they are less efficient than generators of the other types and are less often used than those of the other types.

(iii) In generators of this type the source of the radiation is non-luminous. The current from

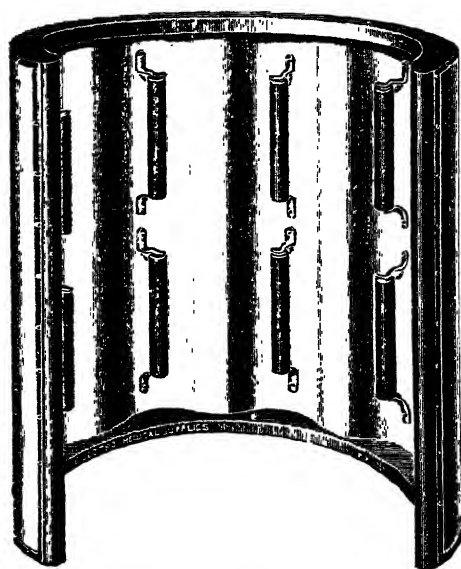


FIG. 60.—Infra-red ray generator fitted with non-luminous radiating elements

the main passes along a metal ribbon and heats it to a degree just short of redness. The metal is an alloy of nickel and chromium. In some models it is wound in the form of a spiral round a porcelain rod. A coating of cement is placed round the porcelain and ribbon. The cement is covered by a dark vitreous enamel. The complete radiating element has the shape of a solid cylinder.

In other models the ribbon lies between two contiguous plates of insulating material, such as micanite. A steel plate is placed in contact with one of the micanite plates, and a layer of asbestos in a shallow tray lies in contact with the other plate. The steel is covered on its outer surface with a layer of dark grey enamel. It is from this surface that the rays are directed on to the patient. The complete radiating element is rectangular in shape. From two to five of these elements are mounted on a suitable support.

Type 2

Type 3

Fig. 60 is an illustration of a generator containing eight radiating elements, each of which is cylindrical in outline and measures about 8 inches in length and $1\frac{1}{4}$ inches in diameter. The elements are mounted in a tunnel-like cabinet which can be placed over the trunk. Smaller cabinets containing six radiating elements can be placed over a limb.

Some infra-red ray generators are made with interchangeable emitters. Either a filament lamp or a non-luminous radiating element may be fitted to the same holder. These duplex generators are small and portable. They are suitable only for local treatment. One is illustrated in Fig. 61.

(2)—Output

The infra-red output of various generators differs both quantitatively and qualitatively. Generators of small size take small amounts only of current and do not yield as great an output of infra-red rays as machines of large size which require currents of higher amperage. The qualitative differences, however, are more important. It must not be supposed that generators of different types yield

an equal output of infra-red rays of all wave-lengths. When the emitter from which the rays are given off is heated not quite to redness, there is a greater output of infra-red rays of longer wave-length than of shorter wave-length. On the other hand, the converse is the case when the emitter is heated to incandescence. Thus, in the Sollux generator with its incandescent emitter the rays that are given out in the largest proportion are those with a wave-length of 1μ . There is also a large proportion of rays with wave-lengths a little shorter (from 1μ to 0.8μ) and a little longer (from 1μ to 1.5μ). The output progressively diminishes as the length of the waves grows longer than 1.5μ . In other words, the Sollux generator yields a large supply of infra-red rays of short wave-lengths belonging to the near region of the spectrum.



FIG. 61.—Generator of duplex type. (a) Non-luminous emitter. (b) Incandescent emitter

Output of
Sollux
generator

Of generator with non-luminous emitters

In the generator with non-luminous emitters (see Fig. 60) the infra-red rays yielded in the largest proportion are those with wave-lengths from about 4μ to 7μ . There is only a minute supply of rays of short wave-length that belong to the near region of the spectrum, and the output gradually diminishes as the wave-length increases beyond 7μ . This generator, like others with non-luminous emitters, is a source chiefly of rays with long wave-lengths that belong to the far region of the spectrum.

Knowledge of the output of infra-red rays from luminous and non-luminous emitters is of more than academic importance. It will be shown on page 392 that the output is one of the important factors in determining the depth to which it is possible to heat by means of the rays.

(3)—Selection

Two types of generator needed

For the practice of infra-red ray therapy it is advisable to have two types of generator, one containing a luminous and the other a non-luminous emitter. Large generators are more useful than small models, because general treatment, as well as local, can be given by their means. The question of the choice between luminous and non-luminous emitters depends on various factors. As already stated, a luminous emitter provides the most penetrating rays, and it should be selected when heat is likely to act directly on the pathological tissue. On the other hand, if the diseased tissue is beyond the reach of the rays, the treatment will be that of the symptoms, and it should preferably be conducted by means of a generator containing a non-luminous emitter, because the periods of treatment can be lengthened when desired, without producing irritation of the skin. This, however, is merely a preliminary guide to the selection of apparatus at the beginning of the treatment. If the patient does not derive relief after a reasonably long trial, a generator of the other type should be used. In practice it is sometimes found that the same disease responds better in some cases to treatment by rays of long wave-length, whereas other cases, clinically similar, derive more relief from rays of short wave-length.

4.—PROPERTIES

Chemical changes

Nearly all the biological (physiological and therapeutic) changes due to the action of infra-red rays are those that would be brought about by heat. But some phenomena raise the question of the power of the rays to produce chemical as well as thermal changes. One of these phenomena is pigmentation of the skin. Pigmentation is often observed on the legs of those who sit for long periods in front of electric radiators. In the practice of infra-red ray therapy it is often noted that patients who have been exposed to generators that contain incandescent emitters complain of irritation of the skin, a feeling which they do not notice if the generator contains a non-luminous emitter. Another phenomenon

which suggests the production of chemical changes has been described by W. Beaumont. He found that some patients complained of discomfort in their eyes. They noted it within two hours of their treatment, and it lasted for six or seven hours. This complaint was made even after exposure to non-luminous emitters.

The nature of any chemical change brought about by infra-red rays is unknown. Whether the therapeutic effects are due in any degree to chemical as well as thermal changes must for the present remain a matter of opinion.

When the infra-red rays pass into the body, there is a transformation of radiant energy into thermal energy. There is a production of heat along their path in the tissues down to the level at which they are stopped, and if there is a sufficient quantity of radiant energy the heat will be sufficient to cause a rise of temperature. When the body is sufficiently near to an infra-red ray generator and the skin exposed to the rays, the surface temperature will gradually rise and can easily be made to attain the maximum value that the skin can tolerate. The tissues beneath the skin will likewise be heated, but there is considerable uncertainty as to the maximum depth at which a rise of temperature can be produced. *Thermal changes*

By exposing the skin to infra-red rays from an incandescent source Sonne found a temperature of 117.8° F. at a depth of 5 mm. when the surface temperature was 110.8° F. When the rays were derived from a non-incandescent source, the temperature at the same depth was 107° F. when the surface temperature was 114° F.

Loewy and Dorno used infra-red rays of long wave-length and found a temperature of 100.4° F. at a depth of 10 mm. to 25 mm. Using rays of short wave-length they noted a temperature of 104° F. at a depth of 25 mm. On the other hand, Bachem and Reed were unable to obtain rises of temperature at more than a relatively slight depth below the surface. They found that the rays from the far region of the spectrum had very little penetrating power, whereas those from the near region were able to penetrate the skin and pass into the superficial fascia.

On account of the discrepancy in the findings noted above it is advisable to study the factors which decide the question of the depth to which the infra-red rays can heat the body. These factors include the penetrating power of the rays, the amount of energy conveyed by the rays, and the action of the circulation in removing heat by convection.

Experiments were made by H. J. Taylor on a layer of horny tissue that had separated from the skin of a subject exposed to ultra-violet rays; he found that it stopped the passage of all infra-red rays with wave-lengths longer than 6μ . From experiments conducted on layers of water in order to ascertain the thickness that would stop the passage of waves of different wave-lengths he found that a layer as thin as 0.05 mm. stopped all the infra-red wave-lengths longer than 2.8μ . As the soft tissues of the living body contain a large proportion of water, it is improbable that tissues at more than a very slight depth below the *Penetrative power*

surface are reached by any wave-length longer than 2.8μ . It may therefore be assumed that the long wave-length infra-red rays, which belong to the far region of the spectrum from 3μ to 15μ , do not penetrate below the epidermis.

Taylor found that a layer of water 10 mm. thick stopped the passage of infra-red rays that had wave-lengths longer than 1.4μ . It is evident then that a slight diminution in the length of the wave is accompanied by a considerable increase in the penetrating power of the ray. There is some ground therefore for assuming that the rays belonging to the middle region of the spectrum are able to pass through the epidermis and superficial fascia and, perhaps, the tissue a little deeper, if the superficial fascia is less than 10 mm. thick.

Infra-red rays that have wave-lengths shorter than 1.4μ have a still greater penetrating power. Some of them, probably those of which the wave-length is almost as short as that of visible red rays, are able to pass through thin parts of the body, such as the hand.

*Wave-length
and
wave-energy*

The power of infra-red rays to heat the tissues below the surface depends not only on their penetrative power but also on their intensity, i.e. the amount of radiant energy they convey. Although the rays with the shortest wave-lengths have the greatest penetrative power, they will not raise the temperature at the maximum depth which they are capable of reaching if they are not present in sufficient quantity. For this reason it is obvious that a generator must not only emit rays of short wave-length but must emit them in sufficient amount, if it is desired to heat parts at more than a slight depth below the surface.

*Heat-
converting
action of the
circulation*

The circulating blood has the power of removing heat by convection. If the heat is removed as fast as it is generated, there will not be any rise of temperature. In parts such as the skin and superficial fascia, where the blood-supply is not large, the amount of heat removed will be small. But in more vascular parts a greater amount of heat will be lost. If the abdominal wall were thin and allowed the passage through it of a sufficient quantity of infra-red rays, it is doubtful if a rise of temperature could be produced in the highly vascular viscera.

There is every likelihood that infra-red rays can heat to a greater depth below the surface than can be reached by the heat derived from hot objects placed in contact with the skin. The actual depth must for the present remain a matter of judgement. One centimetre below the surface would appear to be the maximum.

5.—ADMINISTRATION

*Preparation
of patient*

The part to be treated must be divested of clothing. The patient may be seated when the upper limb, leg, or foot is under treatment, the parts being supported so that they can rest in comfort without moving. He should be recumbent when the neck, trunk, hips, or thighs require treatment. The distance of the generator from the body should be

adjusted so that the patient feels a comfortable degree of heat. When non-luminous emitters are used, the current should be switched on two or three minutes in advance, because the radiating emitters do not at once reach their maximum temperature. When the face is in the path of the rays, the eyes should be protected, a sheet of cardboard being suitable for the purpose. The initial exposure may last for ten minutes. During successive sessions the period should progressively be lengthened until it reaches a maximum of twenty minutes. This time should not be increased when luminous emitters are used, otherwise the irritation of the skin, referred to on page 390, may occur in some patients. The length of the session may gradually be increased to thirty or forty-five minutes if non-luminous emitters are used. The treatment may be given daily or on alternate days.

Length of exposure

6.—THERAPEUTIC USES

The maladies and morbid conditions for which infra-red ray therapy should be prescribed are those for which heat is a rational form of treatment (see DIATHERMY, Vol. IV, p. 31, ELECTROTHERAPY, Vol. IV, p. 490, and HYDROTHERAPY). Infra-red radiation is, in fact, a branch of thermotherapy. If it has any chemotherapeutic action, too little is known of it to serve as a guide in the selection of cases for treatment. Like other thermotherapeutic agents the rays possess the power of relieving pain and spasm and the sensation of cold. They are useful and convenient for the purpose of raising the temperature of parts that are pathologically cold. They aid the resolution of inflammation. Although they do not possess any direct bactericidal action, they possess some power of helping the tissues to free themselves from infection, more especially when the infection is near the surface. They facilitate drainage from wounds and aid healing.

Indications

One of the advantages of using infra-red rays for thermotherapeutic purposes is that they provide a constant and continuous supply of heat that can be maintained for any length of time. Although electrically heated pads in contact with the skin offer the same advantage, it is unlikely that they produce a rise of temperature to the same depth as infra-red rays derived from an incandescent emitter. The heat from the pad can enter the body only by conduction, a process which is slow and, at the same time, hindered by the heat-convecting action of the blood in the subepidermal capillaries. On the other hand, when the more penetrating infra-red rays are used they actually generate heat within the body, and less heat is lost in the less vascular tissue below the subepidermal capillaries.

Advantages

Infra-red rays are unable to heat the body to the same depth as the diathermic current, but their use in the treatment of disease in more superficial situations has much in its favour: the apparatus is simple and there is nothing that gets out of order during its use; and patients do not

need the constant personal attention that must be given to those who are under diathermic treatment.

Although infra-red ray treatment is not followed in any disease by spectacular results after failure of other remedies, there are nevertheless many common maladies for which heat is a rational form of treatment, and which may advantageously be treated by infra-red rays if they fail to respond to a reasonable trial of drugs or simpler thermal measures.

Fibrositis

Of the diseases treated in a fair number of cases by infra-red rays the greatest success has been obtained in fibrositis. Under this heading are included not only the cases in which painful nodules are palpable but others in which there is pain or tenderness in the muscles or fibrous tissues, without the presence of palpable nodules, and which sometimes are named myalgia, myositis, or, if the lumbar region is affected, lumbago. Relief of pain usually follows treatment by infra-red rays. In long-standing cases it is advisable also to administer kneading massage and passive movement.

Peripheral neuritis

Cases which sometimes are diagnosed as peripheral neuritis (brachial, occipital, sciatic) are often examples of referred pain rather than of true neuritis, and a careful search will often reveal nodules of fibrositis or small tender areas in the region of the neck, shoulder, hip, or other part. These are the forms of neuritis which respond best to infra-red ray treatment. The region where the nodules or tender points are elicited should be subjected to the influence of the rays, as well as the parts to which the pain is referred.

Arthritis

In arthritis the action of infra-red rays is beneficial in cases due to trauma, the object of the treatment being the relief of pain and the acceleration of resolution. In osteoarthritis the rays cannot be expected to check the progress of the disease; but, if an osteoarthritic joint is painful or swollen in consequence of injury or over-use, some relief can be obtained from infra-red ray treatment. To rheumatoid arthritis the rays may bring relief during the quiescent stages; but, unless the progress of the disease is arrested by the discovery and eradication of a primarily infected focus, the benefit derived will only be temporary.

Paralysis

Infra-red rays can advantageously be administered to parts which are subnormal in temperature in consequence of paralysis, especially in cases in which groups of muscles exhibit the reaction of degeneration (see Vol. IV, p. 485). Progress towards recovery is delayed by cold, and the action of the ray treatment is to raise the temperature of the cold part. In cases of paralysis in which recovery is long delayed and the onset of contracture is feared it is advisable to suspend treatment by electrical stimulation and to substitute infra-red ray treatment, using a generator with a luminous emitter.

Accessory sinuses

In inflammation of the accessory sinuses the infra-red rays can relieve pain in the early stages, but when suppuration has supervened it is doubtful if they are able to do more than accelerate drainage.

Skin diseases

In some diseases of the skin, e.g. acne vulgaris and furunculosis, the rays have undoubted therapeutic value, more especially in cases which

are not of long duration. If pus has formed, its discharge is accelerated; and, if the inflammation is not purulent, the treatment seems to favour its resolution. Infra-red ray treatment does not appear to have any special value in true eczema, but it is helpful in some cases of the so-called trade eczemas which are forms of dermatitis caused by chemical irritants.

Infra-red rays can play a useful part in the treatment of inflammation following injury. Their use, however, should be withheld until the acute stage has passed. In contusion, sprain, synovitis, and tenosynovitis the treatment may be given daily, and each application of the rays should be followed by massage. When the injury has been so severe as to cause fracture or dislocation, the infra-red ray treatment may be begun about one week after the necessary surgical treatment. The fractures most suitable for treatment are those in the vicinity of joints, such as the wrist and ankle. Massage should be administered after each application of infra-red rays. In traumatic inflammation massage and movement are perhaps more important than ray treatment, but the last mentioned is a useful preparatory treatment.

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HEAT-STROKE AND HEAT-EXHAUSTION

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PATHOLOGIST AND BACTERIOLOGIST TO THE ANGLO-IRANIAN
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Reference may also be made to the following title:

CRAMP

1.-DEFINITIONS

661.] Heat-stroke is hyperthermia due to failure of the body to compensate for a relatively hot environment. Heat-exhaustion is circulatory embarrassment associated with ionic imbalance, also due to a hot environment. This condition is often a prelude to heat-stroke.

2.—AETIOLOGY

The aetiological agent responsible for the phenomena of heat-stroke and allied conditions is simply heat, i.e. the luminous and dark electromagnetic waves extending, roughly, from a wave-length of 5,000 to 8,000 Ångstrom units in the visible range and below 8,000 Å to about 20,000 Å in the invisible or infra-red range (Aron; Freer; Gibbs; Marsh, 1930). Bright and dark rays of heat emanate from the sun; infra-red from secondarily heated moisture-laden air (G. C. Simpson), sun-heated buildings or ground; from molten-metal containers in a foundry (Thorneycroft), or from a boiler furnace, ashore or on ship-board (Fairley; Smith); from the hot humid atmosphere and walls of a deep mine (Haldane, 1905; Moss); or from many different situations increasing with the developing complexity of modern industrial operations. The relation of temperature to working capacity was well shown by Cadman.

Haldane (1905) showed the aetiological importance of moist heat and demonstrated that the wet-bulb thermometer was a most reliable guide and that the limits of a man's power of accommodation were passed when the temperature of still air, as shown by the wet-bulb, exceeded 88° to 90° F., even when the man was stripped to the waist and doing no work; in air moving at two miles an hour the critical wet-bulb temperature rose to about 93° F. The air temperature, wind velocity, and relative humidity (the ratio of absolute humidity to saturation) are all important factors (Hill; G. C. Simpson) and have been combined in an arbitrary expression, 'the effective temperature', by Yagloglou, McConnell, and Fulton, who also define a 'comfort zone'. If the air is dry as well as warm, the wind will increase evaporation and so tend to cool the body; but the warm air and evaporation act in opposite directions, and it is important to know which effect will prevail, for if the warming tendency is greater than the cooling the body-temperature may rise (G. C. Simpson). Normand found that in calm air the normal human body could support an air-temperature of 100° F. if the relative humidity was less than 90 per cent; 120° F. if it was less than 40 per cent; 140° F. if it was less than 15 per cent; but, even though the air was quite dry, death occurred at 128° F. with a wind velocity of 20 miles an hour; at 117° F. with a velocity of 56 miles an hour. These velocities are not unknown to occur in hot desert winds, such as the simoom (G. C. Simpson). In an analysis of fifty cases of heat-stroke, with a mortality of 20 per cent, among British troops in India between June 1909 and August 1910, Pembrey (1913, 1914) showed that in half the cases the wet-bulb was 80° F. or more, in eight cases 84° F. or more, and in five cases 85° F. or more, the highest dry-bulb temperature being 112° F. During the exceptionally hot June-July 1934, thirty-seven cases of heat-stroke among Chinese were observed in Shanghai, 64·8 per cent being

Moist heat

Air temperature, wind velocity, and relative humidity

unconscious on admission and the mortality 35 per cent; wet-bulb temperatures oscillated between 80° and 85° F., and dry-bulb temperatures reached 104° F. (Chun). Rogers (1908) showed that a mean temperature of 108° F. and a maximum of 118° F. with relative humidity less than 60 per cent. or a relative humidity more than 60 per cent with a mean temperature of 98° F. and a maximum of 108° F., were dangerous. Smith described a U.S.A. battleship in 1925 in the engine-room of which wet-bulb temperatures were 110° F. and dry-bulb 130° F.; eighty-two cases of heat-stroke occurred. It is generally agreed (Willcox, 1920, b) that heat-stroke cases for the most part occur at the end of or during a spell of exceptionally hot weather (dry-bulb 110° F. significant, dry-bulb 120° F. very dangerous), as pointed out by Rogers (1908) and supported by my experience (Marsh, 1930) and that of Morton, who showed that 120° F. appeared to be a dangerous level under the dry atmospheric conditions then prevailing in Baghdad.

*Effect of
heating
brain tissue*

In any of the circumstances above described the human body may be exposed to heat of such quality or intensity that the natural powers of cooling are nullified or overwhelmed and the body-temperature rises, thus increasing the respiratory and nitrogenous exchanges (Sutton) and causing not only retention of heat but actual over-production (Brooke), the body-temperature increasing to a noxious or fatal degree, heat-stroke proper. It was shown by Halliburton and Mott (1903) that *in vitro* a temperature of 108° F. coagulated a watery extract of human or animal brain tissue (grey matter) in three hours, but that temperatures of 104° or 105° F., kept up for eight hours, did not produce any effect. Wood showed that heating the brain of animals caused insensibility at 108° F. and death at 113° F. and that the myosin of the heart coagulated at 115° F. Marinesco found in experiments on animals that a temperature of 116.6° F. was immediately fatal; 113° F. killed in an hour or two; and a temperature of 109.4° F. killed after a longer period. Rogers (1908) found that the mortality of patients with a temperature of 107° F. was 8.3 per cent, with a temperature of 107° to 109° F. was 29.2 per cent, and with a temperature over 109° F. was 69.2 per cent. Gauss and Meyer in Chicago reported the following mortalities of heat-stroke cases relative to temperature on admission: 109° (26 per cent) and 110° (81 per cent), the highest temperature observed being 114° F. Lambert recorded the highest temperature in the literature, 117.8° F., and recovery after 115° F.

*Effect on
heart*

Not uncommonly the effort of the body to counteract the forces of heat throws too great a strain on the heart muscle (Barcroft and Marshall), which may be already embarrassed by ionic imbalance (Marsh, 1932; Lee), or by depleted reserve power due to age (Shattuck and Hilferty), or by some other factor, and, even before an actual rise of body-temperature has occurred, syncopal or asphyxial (Pembrey, 1914) symptoms may supervene, and the case become one of heat-exhaustion, which may be a prelude to hyperthermia. If the bare head of a man, whose body is already in a state of pyrexia, is exposed to the bright

midday tropical sun. local heating to a depth of one or two centimetres of the skull surface and subjacent structures, including some brain tissue, may occur with serious consequences (C. J. Martin), although monkeys (Aron), rabbits (Marsh, 1930), or swimming men (Marsh, 1930), all with artificially cooled bodies, may expose their heads to the most intense tropical sunlight with impunity.

The older hypotheses, which ascribed heat disorders to the effects of ultra-violet radiation (Puntoni; Brooke), or to a mysterious penetrating ray peculiar to tropical sunshine, or to infection with a specific micro-organism (Sambon, 1898; Manson), are now all discredited (Rogers, 1908; Aron; Pembrey, 1913, 1914; Ogilvie; Mackenzie and Le Count; Willcox, 1920, b; Barbour, 1921; C. J. Martin; Marsh, 1930; Morton; Castellani), although it must be admitted that many cases of heat effects are complicated by microbic, protozoal, or virus disease which greatly furthers the noxious effect of environmental heat by hampering and disorganizing the very complex thermotactic mechanism of the human body. It is also necessary to state that ultra-violet radiation may have profound effects on the body if this is naked, unprotected by pigment, or subject to hydroa vacciniforme (Rasch) (see p. 93).

3.—PATHOLOGY AND MORBID ANATOMY

Blood chemistry

The syndrome of heat effects is constantly associated with the following characteristic changes in the chemistry of the blood.

In fifty normal men in cool weather the mean blood chloride was 494 mgm. per 100 c.c.; standard deviation ± 38 mgm. per 100 c.c. In hot weather the mean was 466 mgm. per 100 c.c.; standard deviation ± 29 mgm. per 100 c.c. In forty-five patients suffering from heat effects with achloruria the mean was 448 mgm. per 100 c.c.; standard deviation ± 52 mgm. per 100 c.c. (Marsh, 1933, and unpublished observations).

In fifty normal men in cool weather the mean plasma bicarbonate was 2.78 millimols per 100 c.c.; standard deviation ± 0.26 millimol per 100 c.c. In hot weather the mean was 2.54 millimols per 100 c.c.; standard deviation ± 0.18 millimol per 100 c.c. In one case of heat-stroke there was 0.61 millimol per 100 c.c. and in one case of heat-exhaustion there were 2.1 millimols per 100 c.c. (Marsh, 1933, and unpublished observations).

In fifty normal resting men in cool weather the mean blood lactic acid was 24 mgm. per 100 c.c.; standard deviation ± 6 mgm. per 100 c.c. In hot weather the mean was 30 mgm. per 100 c.c.; standard deviation ± 9 mgm. per 100 c.c. In one case of heat-stroke there were 100 mgm. per 100 c.c. In heat-stroke in dogs and rabbits there were up to 400 mgm. per 100 c.c. (Marsh, 1933, and unpublished observations).

Marked dehydration is associated with an increase in the percentage of haemoglobin to 110 per cent or more and an increase in the red cell

- Red cells* count to 6,500,000 or more. There is also an abnormally wide difference between the plasma and the whole-blood chloride (Marsh, 1933). The
- Leucocytes* leucocyte count is slightly increased as a rule, the differential count not
- Blood urea* being significantly altered. Blood urea was increased in one case (Marsh,
- Blood-sugar* 1933) to 120 mgm. per 100 c.c. Blood-sugar was increased also in this case to 210 mgm. per 100 c.c.
- Experimental heat-stroke* Experimental heat-stroke in dogs (Wakefield and Hall, 1927, b) and in rabbits (Marsh, 1933) is constantly associated with high blood lactic acid, low plasma bicarbonate, high blood-sugar, and, occasionally, with high blood urea.
- Urinary changes* The earliest sign of impending hypochloraemia in man is low or absent urinary chlorides. A valuable rough test is to take 5 c.c. of the patient's urine in a test-tube; five drops of pure concentrated nitric acid and a few drops of a 1 per cent solution of silver nitrate are added. Normally a thick curdy white precipitate appears; a slight haze or no change indicates that chlorides are absent from that specimen. Cases in which severe chloride depletion has occurred may require treatment with 1 to 2 ounces of salt powder (sodium chloride) a day for a week or more before chloride can again be demonstrated in their urine.
- Sugar and acetone are occasionally found in the urine of affected persons; and, very occasionally, albumin in traces and a few hyaline casts.

Morbid anatomy

- Just before death from heat-stroke the muscles become very stiff; a few minutes after death, or even during the process, rigor mortis comes on, and exaggerated post-mortem movements take place.
- Early rigor mortis*
- Cyanosis* The face, mucous membranes, and body surface are deeply cyanosed; in rare cases numerous minute petechiae are seen in the subcutaneous tissues of the face, neck, and chest, and in the intercostal muscles and accessory muscles of respiration. The lungs are heavily engorged;
- Lungs*
- Brain* the veins and capillaries of the brain are so deeply congested that an unexperienced observer may wrongly diagnose cerebral haemorrhage.
- Heart* The heart muscle is hard to the touch and contracted in firm systole, the
- Blood* ventricular cavities being almost completely obliterated. The blood in the veins is dark and fluid.
- Rectal temperature* The rectal temperature may continue to rise for an hour or more after death; this phenomenon, however, is not necessarily distinctive of death from heat-stroke.
- Histological changes* Cloudy swelling and early necrosis have been described in the parenchymatous cells of the brain, liver, and kidneys (Wakefield and Hall, 1927, b), but it is doubtful if these were ante-mortem changes; degeneration and autolysis take place with such rapidity during and after death from heat-stroke that it is impossible to draw any conclusion from material taken after death.

4.—CLINICAL PICTURE

(1)—Heat-Stroke

The patient is admitted unconscious, with the face suffused or cyanosed, a hot dry skin, a bounding pulse, stertorous breathing, a rectal temperature of 108° to 112° F., and urinary and faecal incontinence. Sometimes heat-stroke develops in a patient under treatment in an uncooled ward for some intercurrent disorder, and cessation of sweating may be a warning sign in such cases (Hearne, 1919). Less severe cases are seen if the patients are brought in early. 'Flash' cases which develop in a night are seen occasionally in young unacclimatized men or in elderly persons.

(2)—Heat-Exhaustion

The patient walks or is brought to the out-patient department complaining of weakness, languor, limpness, lassitude, weakness in the legs, exhaustion, faintness, dizziness, nausea, anorexia, abdominal discomfort, headache, constipation, sleeplessness, and mild or severe cramps in voluntary muscles. The patient may have fainted at his work and be carried in semi-conscious. Many patients faint while having their fingers pricked or veins punctured for blood samples. Diarrhoea and vomiting are common symptoms. The pulse is rapid and of low tension, the expression is anxious, and there may be a temperature of 103° F. in the mouth. The skin may be moist or dry; sweating is usually not profuse. The temporal hollows and cheeks fall in.

5.—COURSE AND PROGNOSIS

In severe heat-stroke death is a not uncommon termination, unless *Heat-stroke* the patient can be brought under medical care very early in the course of the disorder. With prompt and effective treatment many patients can be saved, but this is an outstanding instance of a disorder for which prevention is much superior to any known cure. Heat-stroke complicated by any other disease has a much worse prognosis than the uncomplicated form. Even with a temperature of 109° F. recovery may take place if the patient has not been unconscious for more than one and a half hours; but not after three hours (Rogers, 1908). The mortality of patients admitted to hospital with heat-stroke has been given above (see p. 398).

The immediate prognosis of a case of severe heat-stroke is gloomy; but, if the acute symptoms subside under treatment, consciousness is regained rapidly, and no complications arise, the ultimate prognosis is good. In heat-exhaustion, on the other hand, recovery is the rule, *Heat-exhaustion* except in persons over sixty years of age (Shattuck and Hilferty), and a fatal termination is rare except in those neglected cases which go on to develop heat-stroke.

Complications The commonest complication of heat effects is some intercurrent disorder, such as malaria, sand-fly fever (Sinderson), or enteric (typhoid and the paratyphoids); another common complication is diabetes mellitus, usually of mild degree, or temporary depression of the antidiabetic function of the islets of Langerhans in the pancreas. There is some evidence that depression of function of the adrenals occurs occasionally (Mills); Cramer found that exposure to heat inhibited the activity of the adrenals and led to disappearance of the cortical lipoid. Loeb and his co-workers showed that hypochloræmia and dehydration were important factors in Addison's disease, in which adrenal insufficiency was the prime factor. Cramer's experiments on the cortical lipoid of the adrenals were contradicted by the work of Raymond Whitehead; but, although the results may vary according to the technique used, Cramer's deductions are apparently supported by other workers (Cramer). Long-continued high body-temperature may damage the cells of the grey matter of the brain, shown by mental confusion, mania, or cerebellar disturbances (Stewart, 1918), or by dementia (Eric Jamieson, private communication). Damage to the parenchymatous tissue of the kidneys may be shown by the presence of albumin and casts in the urine with raised blood-urea (Wakefield and Hall, 1927, a). Sometimes too vigorous salt therapy results in wide-spread oedema with a nephritic distribution, which soon disappears on resumption of bodily activity by the patient but may demand the temporary cessation of salt treatment. Convulsions, congestive heart failure, pulmonary oedema, cyanosis, and delirium are said to respond best to prompt venesection to the extent of eight or ten ounces, undertaken while the cooling treatment is in progress (Willcox, 1920, a).

Malaria It may happen that, if the associated disorder is malaria, it cannot be diagnosed during the first twenty-four, forty-eight, or seventy-two hours, repeated blood films proving negative; yet a blood examination conducted four days after admission may reveal malarial parasites; such cases have occurred in my experience.

Cerebral malaria In cerebral malaria, in which the parasites are not demonstrable in the peripheral blood, failure of the patient to recover consciousness when the rectal temperature is reduced to 102° F. should direct the medical attendant's attention to this possibility, and after the exclusion of uræmia, diabetes mellitus, poisoning, and a history of long-persisting hyperpyrexia, a diagnostic intravenous injection of a solution containing 9 grains of quinine dihydrochloride should be administered and the effect on the patient's symptoms carefully noted during the ensuing two or three hours; a favourable result may be an indication to repeat the injection. A well known sequel of heat-stroke is persistent headache, said to be relieved by subtemporal decompression; impairment of memory, which may persist for years, is also recognized; greatly increased sensibility to the effects of alcohol may be one of the more immediate sequels, and a temporary spastic paralysis of one or more extremities has been observed.

Recurrences of heat-stroke when a treated patient returns to his hot environment have been described (Willcox, 1920, b), and continued pyrexia after the hyperpyrexia had subsided is described by Willcox (1920, b) and may last as long as three weeks (H. H. King). A continued low pyrexia in steel workers as the result of heat is described by Talbot and others.

Recurrences

6.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

A well equipped and, if possible, cooled laboratory, capable of dealing with bacteriological, pathological, and biochemical problems in a competent manner, and with ample staff for dealing with the rush of work that occurs in any emergency, is indispensable for the proper diagnosis of tropical diseases and especially for the investigation of cases of heat effects, which may be, and quite commonly are, complicated by almost any other disease known in temperate or tropical climes.

Patients who on admission are hyperthermic and comatose and do not respond quickly to cooling treatment need blood and other examinations to exclude or identify protozoal disease, uraemia, diabetic coma, enteric fevers, typhus, septicaemia, anthrax, alcoholism, epilepsy, opium poisoning, carbon monoxide poisoning, hydrogen sulphide poisoning, and head injury. It may be necessary to wash out the patient's stomach.

Blood

The urine must be examined for albumin, sugar, haemoglobin and red cells (highly suggestive of snake bite), abnormal blood-pigments, acetone, diacetic acid, chlorides (quantitative), hydrogen-ion concentration (pH colorimetrically), casts, and pus cells. The cerebrospinal fluid should be examined, the approximate pressure recorded, and the presence of pus cells and micro-organisms (e.g. streptococci, meningococci, and tubercle bacilli) in direct smears and cultures ascertained. Excess of albumin and globulin with a raised cell count may suggest cerebral tumour; blood pigment, an injury. Sugar, chlorides, and urea may be estimated quantitatively with advantage. Uncomplicated heat-stroke is accompanied by hypochloraemia, dehydration, absence of urinary chlorides, and excess of lactic acid and low content of bicarbonates in the blood (Wakefield and Hall, 1927, b; Marsh, 1930). Occasionally the diagnosis can be established only at necropsy, at which yellow fever, spirochaetosis icterohaemorrhagica, plague, or some obscure condition may be revealed. It should not be assumed that patients admitted dead with a very high rectal temperature have necessarily succumbed to heat-stroke; very high rectal temperatures after death are found in tetanus, hydrogen sulphide poisoning, strychnine poisoning, hydrophobia, anthrax, cerebral malaria, and other conditions.

Urine

Cerebro-spinal fluid

Patients admitted hyperthermic and perhaps comatose, who respond quickly to cold therapy by recovery of consciousness and a falling rectal temperature, must also be rapidly and carefully investigated with the object of discovering and treating any associated malady.

High rectal temperature

Patients admitted with the symptoms, mild or severe, of heat-exhaustion are usually in the majority, and mild cases may flood the out-patient departments and dispensaries after or during a heat-wave, or after a rumour has gone round the community that a patient with severe heat-stroke has been admitted to, or has died in, hospital. It is difficult to differentiate cases of pure fright from genuine examples of mild heat-exhaustion, as heat effects in man are so greatly influenced by the mental state of the patient (Marsh, 1935).

Routine examination in mild heat-exhaustion

As a routine the rectal temperature, pulse and respiration rates, and diastolic and systolic blood-pressures should be recorded when the patient is first seen and again after he has been sitting quietly for half an hour in the waiting-room. A specimen of urine should be obtained and quickly examined for reaction, specific gravity, albumin, sugar, acetone, and chlorides (for rough test see p. 400); it should be also examined microscopically. The patient's complaint should be listened to and carefully recorded; there may be a long story of faintness, exhaustion, malaise, cramps, twitchings, vomiting, and various unexpected symptoms, depending on what the patient has learned from other sufferers or books of travel. On the other hand, the patient may complain simply of constipation or of absence of sweating (Hearne, 1919). Frequency of micturition has also been described (Longmore).

Cramp

Real cramps are a valuable diagnostic sign; the patient, if he has a cramp, cannot sustain a conversation; he can show the observer the exact position (of a true one), and the affected muscle can be felt to contract forcibly and remain like a hard subcutaneous metal bar to the touch for a fraction of a minute or longer. True cramps are exceedingly painful, and the site often remains sore for a day or two afterwards. A low systolic blood-pressure, absence of chlorides from the urine, and a rectal temperature of 100° F. or more after the half-hour's rest are all indications that the patient should be admitted to hospital for observation and further investigation.

Indications for further investigation

'Flash' hyperpyrexia

Patients aged fifty or more years, or younger men who have been introduced to a hot climate without having time to be properly acclimatized, should be examined very carefully and disposed of with caution, for they may develop the rare 'flash' hyperpyrexia without premonitory signs, and, if dismissed cursorily, may die in their quarters before medical aid can be obtained. This possibility should always be borne in mind, and every patient should be asked his age and length of residence in the area. Heat-exhaustion as a cause of death from heat effects is the predominating factor in people over sixty years of age; the correlation of heat deaths with increasing age is probably due to the progressive diminution in the reserve power of the heart (Shattuck and Hilferty).

A valuable measure would be to record the oxygen consumption and basal metabolism in all patients suspected to be suffering from heat effects and to compare the results with those of a large group of normal men under the same summer conditions. This work is about to be

undertaken at the Anglo-Iranian Oil Company's hospital in Masjid-i-Suleiman. The measurement of the humidity and temperature of the air beneath the patient's clothing may afford valuable information (Marsh and Buxton).

7.—TREATMENT

(1)—Prophylactic

(a) *Air Conditioning*

The surest method for the prevention of heat effects in man is adequate artificial control of the environment. Outstanding examples of this practice are the scheme of refrigeration in operation at the Morro Velho Mine in Brazil (Davies) and the air-compression system of Egan. Other efficient methods are in use in industry in many parts of the world; they involve methyl chloride or ammonia refrigerating machines, or even, in favourable circumstances, use of the cooling powers of evaporating water at atmospheric pressure and *in vacuo* (Moyer and Fittz). Air conditioning of dwellings is a commonplace in the city of New York, U.S.A., and other less progressive organizations will in time no doubt follow this lead. There are no practical difficulties involved in air conditioning a dwelling or work-place in any part of the world; the only drawback is the expense involved. Failing complete control of the environment, we fall back on partial measures, or the nearest to the ideal that is available, and balance our mechanical deficiencies by developing to the utmost those powers of personal resistance which are included in the very comprehensive term acclimatization.

An undertaking of inestimable value for dwellers in very hot environments is the provision of specially cooled wards (Rennie; Marsh, 1930) in a general hospital for the reception of cases of heat effects. The heat-stroke ward at Masjid-i-Suleiman, which was the first of its kind in the world, was originally conceived, designed, and built in 1926 by Dr. Eric Jamieson. Ideally the whole of the accommodation in any hospital situated in extremely hot surroundings should be artificially cooled. There should be accommodation for ten per cent of the population at risk, in order to provide for the rush of cases that occur with a heat-wave. A cooled room should be available on ships which have to voyage under summer conditions in climates such as the Iranian Gulf. Dudley recorded a dry-bulb temperature of 117° F. and a wet-bulb of 92° F. in the switchboard room of a cruiser.

(b) *Acclimatization*

Some organizations ignore air conditioning completely and depend entirely on the fitness and good acclimatization of the workers. Such is the policy in the Witwatersrand Gold Mines, South Africa, where candidates for employment are subjected to test in rooms artificially heated to 94° F., wet-bulb (Cluver), and are then graded on their reactions, suitable candidates being put through a further course, involving exposure to high temperatures in stages, and lasting, in the case of

the most refractory of the subjects chosen, fourteen days. This policy is found satisfactory for manual workers, whose active time is divided into shifts, who do not require much technical skill, and who live (out of working hours) and sleep in an equable climate. The medical officers of the Witwatersrand Gold Mines found (Cluver) that fewer casualties from heat occurred among men born and bred in hot climates than among men brought up in more temperate countries.

Wakefield and Hali (1927, a) from their analysis of heat effects among stokers in the American Navy, and Mills and Ogle from experiments on animals and an analysis of heat effects occurring in the United States of America, also concluded that men brought up in hot environments suffered fewer serious ill effects than men brought up in temperate zones. The well known resistance of natives of India, tropical Africa, Arabia, and other hot climates to hot environments, a resistance usually only broken down by malaria or typhoid (Willcox, 1920, a), is an example of perfect acclimatization. The degree of acclimatization necessary for a worker in the 'brown tropics' (maximum shade temperature about 120° F., dry-bulb, and 72° F., wet-bulb), who not only works but eats, sleeps, rests, and recreates in his hot environment for months on end, is built up only slowly over a period of months (Marsh, 1935) and depends on many factors in addition to habituation to extreme heat. Such acclimatization is near the human limit, and neglect of the process or attempts to hasten it unduly will end in disaster (Marsh, 1935). The induced state is akin to the condition of an athlete in training. It is well known that bodily fitness for a feat of speed, skill, or endurance can only be acquired very slowly, and proficiency and fitness are easily lost at any stage in the process of preparation if the subject is the victim of intercurrent disease, or if he disobeys any of the strict regulations laid down for those in training. Moreover, no athlete will benefit by the most strict training if his mind is not attuned to the process. These considerations apply with almost equal force to the subject for acclimatization, who should be a young adult, free from organic disease or inherited defects, imbued with correct notions of personal hygiene, and desirous, by reason of some powerful motive, of undergoing the trials, discomfort, and self-discipline associated with the preparative and fully developed stages of acclimatization; for this, in its most complete form, is required of any person who undertakes heavy muscular work in extremely hot climatic conditions. To enable the worker to exploit his trained state to the utmost, he must not only be protected from intercurrent disease but have a proper allowance of rest and sleep in moderately cool surroundings, sufficient recreation, and a properly adjusted diet containing ample salt, ample supplies of all vitamins, and ample cold pure drinking-water; and he must wear loose airy clothing of thin material, preferably white in colour (Gibbs; G. C. Simpson), light, shady, ventilated, and well insulated (aluminium foil, Castellani and Scotti) head-gear and, out of doors, tinted glasses to neutralize the glare.

*Time
factor in
acclimatiza-
tion*

*Suitable
subject for
acclimatiza-
tion*

Such complete training is by no means required for all residents in the tropics. It is a curious fact, attested by the experience of many medical men long resident in the hottest climates, that women of the prosperous class are rarely or never victims of true heat-stroke. The explanation seems to be that such women live sheltered lives and do not undertake strenuous bodily exertion in hot surroundings, a deduction which is supported by the fact that women of the labouring or agricultural classes do not enjoy such immunity. Cases of heat-exhaustion among sheltered women are not uncommon in hot weather and are often complicated by a strong psychoneurotic factor. Persons whose mode of life is intermediate between that of the sheltered women and the young men doing heavy muscular work in the heat require a modified degree of acclimatization, easily attained, if the subject is young and healthy, and well within the powers of the very young and the elderly, provided that certain elementary rules of domestic and personal hygiene are observed, which should be common knowledge among all members of any tropical community.

*Incidence
among
women*

(c) *Living Quarters*

Dwelling quarters should be constructed of strong non-conducting material with a double roof enclosing a wide air space, or a thick thatched roof, projecting well over and shading the upper wall. A ventilated verandah all round the house, supporting at its periphery contiguous hanging curtains of strong canvas, surfaced on both sides with aluminium foil (Crowden, 1934, a), reaching to the ground, and capable of being rolled up easily, is an important feature; the curtains convert the verandah into an air buffer during the heat of the day. Double walls should be used, the hollow filled with large fragments of coke-breeze or cork and cement (Keane), and the whole thickness perforated by numerous clerestory windows near the ceiling. Buildings should be so constructed, by design and in materials, that they do not retain heat tenaciously but, given the opportunity, cool down quickly.

Verandah

Double walls

The design should enable the occupier to trap a maximum quantity of cool night air. The house should therefore be very lofty and capacious (Keane); there should be provision for thorough ventilation of the whole building with rapid streams of cool night air, which should drive out and take the place of the hot air left from the day and cool down the walls and interior, an effect which will be facilitated if the walls are hollow and have special ventilators fitted so that hot air collected in the hollow space during the day can escape at night and be succeeded by cool air; the double roof should have similar ventilating devices; the ideal is a house cooled down to the minimum dry-bulb temperature of the previous twenty-four hours. Although a house should be capable of being cooled down very quickly, it should resist the heating effects of the sun's rays and the hot atmosphere; the air cushion enclosed in the verandah will be a great help, and the walls will be shaded from the direct rays of the sun, a most important provision. The exterior of the

Ventilation

Roof

roof should be whitewashed or covered with aluminium foil (Crowden 1934, b); the glare does not matter in a country where everyone wears tinted glasses out of doors. In some hot countries, however, the night air is nearly as hot as the atmosphere during the day, and even in countries which normally enjoy cool nights regular spells of weather occur during which the nights are suffocatingly hot. Only a scheme of effective air-conditioning can deal with such unfavourable climatic conditions.

(d) *Domestic Hygiene*

*Opening up
and shutting
down the
house*

Given a well designed and constructed dwelling, the daily routine of opening up and shutting down must be carefully regulated. Verandah curtains should be rolled up at sundown, and all ventilators and windows should be opened about 9 p.m. and a free passage of air allowed through the house all night; windows and ventilators should be closed and curtains let down about one hour after sunrise. This routine will be delayed or interrupted by nocturnal dust-storms and exceptionally hot nights, which make opening up inadvisable, but the lost ground can sometimes be made up by taking full advantage of the first cool night. The hot nights must be endured, and some sleep can be obtained by lying under a ceiling fan and drinking copious draughts of cold water. On cool nights it is better to sleep outside with the bed on a grass lawn, if possible.

*Avoidance of
intercurrent
disease*

Great care should be taken to avoid intercurrent disease; every member of the community over the age of two years should be inoculated with antivarious vaccine and injected with T.A.B.C. vaccine before immigration and thereafter at regular intervals of five and two years respectively. Houses should be mosquito- and fly-proof; all beds should be fitted with mosquito or sand-fly nets; pantries and cook-houses should be kept scrupulously clean and the fact verified by frequent personal inspection; drinking-water should be boiled and poured from the kettle into a metal tank in the household ice-chest rather than into bottles, which with their corks are handled by indigenous servants.

*Treatment
of food*

Fruit and vegetables to be eaten raw should be soaked in 1 in 2,000 aqueous potassium permanganate solution for one hour before consumption. All milk should be boiled. Butter and cream produced locally should be pasteurized. Sandwiches made by servants whose cleanliness cannot be completely depended upon are undesirable. Cold soups and meat jellies are best avoided. Household servants should be submitted to a strict medical examination before employment; microscopical examination of their stools for amoebic cysts and helminth ova, a routine urine test, and, whenever indicated, a blood Wassermann reaction, and stool culture for enteric organisms should be performed. A servants' bathroom containing a cement or galvanized-iron bath and running water should be available, as well as a servants' latrine, which should be cleaned daily by a sweeper. Only household servants should live in the bungalow compound; their wives and families should be housed some

*Examination
of servants*

distance away, if possible a mile or more. Cases of fever or other illness among domestic servants or their dependents should be notified at once, diagnosed carefully, and treated promptly.

(e) *Personal Hygiene*

Exercise is a necessity, among other reasons as a stimulus for sweating (Whitehouse), for those in sedentary occupations. If the subject's work involves much muscular activity, exercise is unnecessary but may be undertaken for pleasure. When facilities are available, squash rackets played once or twice a week or one or two sets of tennis every evening (Morton) will give a sedentary worker all the exercise he needs. Exercise

Sleep is most important; the afternoon sleep, the sleeper lying naked under a fan, is often difficult to secure but may be induced by a glass of beer. At night about two pints of cold water should be drunk just before retiring. Broken nights are common in hot weather, and a few sleepless nights are to be expected; arrears of sleep must be made up as best one can. It is sometimes impossible to foresee the spells of bad weather; so it is a good principle to take full advantage of any opportunity for slumber and to avoid mid-week late nights in the summer, reserving the night just before the week-end holiday for any late evening engagements. Sleep

Diet can be a very difficult problem; it is so often a case of Hobson's choice. A good, extensive, well-watered, and cared-for kitchen-garden is an absolute necessity. Bazaar fruit and vegetables, when obtainable, should be examined very carefully and only sound produce purchased. All the known vitamins should be included in the diet by exploiting local resources to their utmost; when these fail it is useful to remember that tinned tomatoes, cod-liver oil (or vitamins A and D concentrates), and marmite may tide over a period of want. The heavier meals should be breakfast and evening dinner; lunch and afternoon tea should be reduced to a minimum. At least ten and up to twenty grams of salt (sodium chloride) should be included in the diet every twenty-four hours (C. J. Martin); these quantities may be doubled with advantage. The only reliable method of ascertaining whether enough salt is being ingested is by estimating the salt excreted in a twenty-four hour specimen of urine, which should always contain more than three grams (Talbot and Michelson). Diet

Drink is an all-important problem in the tropics and has attracted more attention than any other branch of personal hygiene, probably because of the violent division of lay opinion on the subject. There is general agreement among medical practitioners in tropical zones that excessive alcoholic consumption is definitely contra-indicated. The well known saying of Sir Charles Napier, in which he explained his immunity from the serious results of heat effects, 'I do not drink. That is the secret. The sun hath no ally in the liquor among my brains' (W. J. R. Simpson), is often quoted by the temperance school. That 'pure water is a poison' (MacKeith *et al.*, 1923) was first demonstrated by Rowntree, yet profound effects may arise from shortage of water alone (J. H. King). Drink

- Water* Hunt showed that up to three gallons of drinking-water a day were necessary for a man walking about at his work in the heat during summer-time in the Deccan. Eighteen litres of drinking-water a day were necessary for labourers on Boulder Dam, California (A. J. Scholl). Cold water is a necessity; eight, sixteen, or twenty-four pints a day may be required by an adult, and the 'poisonous' property is neutralized by the addition of sodium chloride, in the proportion of half an ounce of salt to a gallon of water (Hancock, Whitehouse, and Haldane).
- Alcohol* There is no evidence that alcohol in strict moderation is harmful to the resident in the tropics who is careful of personal hygiene, and it is undoubtedly better drunk in the evening, just before a meal. Morton complained of the 'windy insufficiencies' of teetotal drinks in the tropics, and suitable non-alcoholic drinks have not received the attention that they deserve.
- Bowels* Constipation is such a universal complaint in the hot season that it almost merits the title of 'physiological'. The body is greedy of water, and only the minimum is lost in the stools. A very popular remedy is the routine weekly dose of magnesium sulphate or Eno's fruit salt every Sunday morning, no attention being paid to bowel irregularities during the week. The severely restricted choice of foodstuffs during the summer is a big factor in the production of constipation and its attendant evils. Fresh fruit, stewed prunes, the skins of boiled potatoes, and any other locally available form of 'roughage' should be exploited and the routine week-end dose of saline purgative used when other more physiological measures fail.
- Clothing* Clothing by day should be loose, light, and thin; white is the colour of choice (G. C. Simpson), because it reflects a large percentage of the visible heat rays. A short-sleeved tennis-shirt, thin cotton coat, and trousers suffice. In the evening similar clothes but black or brown in colour may be worn; dark or infra-red heat is not reflected by any colour (G. C. Simpson). White canvas or leather shoes are very comfortable in the day-time; socks should be changed twice a day. Sandals are suitable for shipboard or indoor occupations. Mosquito boots of thin leather are a much appreciated protection when dining out of doors. Sleeping-suits of thin cotton, any colour, made very loosely, are most suitable; on very hot nights it may be necessary to sleep nude with a towel round the waist. For head-gear a tropical helmet with an aluminium foil layer in the crown (Crowden, 1934, b; Castellani and Scotti) is the most suitable day-time wear.
- Head-gear*

(f) Medical Precautions

- Examination of candidates* It is the duty of all medical men in charge of public health districts or communities of people in hot climates to make sure that everyone in their charge is familiar with the above hygienic principles and, in so far as it lies in their power, to see that the directions are carried out and proper facilities provided for that purpose. Candidates for employment in hot districts should be submitted to a very careful

medical examination, including a detailed case history; and, if the person has not had any previous service in really hot climates, it is advisable to put him or her through a series of physiological tests in a hot room (Glock), noting the pulse index and the ability to sweat, and recording the results for future reference. The pulse index is the pulse-rate for two minutes immediately after exercise divided by the pulse-rate for two minutes before exercise, exercise being a standard one on a bicycle ergometer performed under normal and low-cooling air conditions. When data have accumulated, it should be possible to select suitable candidates on the hot-room results. An attempt should be made, using the case history and any other information that can be elicited, to assess the psychological status of each candidate, and the facts and conclusions should be recorded in the employee's confidential file for future reference by medical officers.

When, in the opinion of meteorological observers, a period of exceptionally hot weather can be forecast, the information should be conveyed to the medical officers and to persons responsible for the hours of work of men performing tasks involving much exposure to direct sunlight or muscular work in normally hot surroundings, so that only the absolutely essential tasks are performed, so long as the heat-wave lasts, by men who are frequently relieved. In India during recent years it has been the practice of the Indian Meteorological Department to warn all military stations when it is anticipated that the wet-bulb thermometer will reach 80° F. in the course of the day, so that all unnecessary exercises may be stopped (G. C. Simpson). This is a policy that could be imitated with advantage wherever cases of heat-stroke are known to occur. In hot weather normal hours of work should begin at sunrise and end not later than midday.

Patients admitted to the uncooled wards of a hospital in hot weather, or treated in uncooled quarters, should not be anaesthetized in the heat, nor should they be given atropine (Love; Hall), stramonium (H. A. Cooper), thyroid extract, weight-reducing agents of the dinitrophenol group (Devegney), large doses of morphine, or any drug which unduly stimulates metabolism, hampers heat loss, or in any way interferes with the mechanism of heat regulation in the body.

The early diagnosis of cases of heat effects will effectually prevent the justly dreaded hyperthermic complications, and to that end it is advisable to warn all persons to report at dispensaries or out-patient departments if they feel feverish or unwell during hot weather. For sleeplessness the following mixture is a safe and effective remedy and in smaller medicinal doses may be repeated every night for two years without harm (Craig):

Chloral hydrate	—	—	—	—	10 grains
Potassium bromide	—	—	—	—	10 grains
Syrup of balsam of tolu	—	—	—	—	1 fl. drachm
Water	—	—	—	—	to ½ fl. ounce

Weather forecasts

Hospital patients

Periodic instructions

Every year, a week or two before the hot season, it is convenient to remind people of the principal points in hot-weather hygiene. Responsible persons in outlying areas and ship's officers should be instructed in the first-aid treatment of cases of heat-stroke and heat-exhaustion. Employers should be warned of the dangers of exposing insufficiently acclimatized men to the full force of the summer heat. The medical profession in hot climates should press for cooled wards, cooled pathological laboratories, cooled operating theatres, and cooled living and, if possible, working quarters, using their influence with responsible bodies to get these reforms executed.

(2)—Curative*Emergency measures*

The patient who is comatose and hyperpyrexial when first seen must be treated without more than a few minutes' delay (Willcox, 1920). It has been shown (Rogers, 1908) that even with a temperature of 109° F. recovery takes place if the patient has not been unconscious for more than one and half hours, but not after three hours. If the cooled ward of a hospital is within a few minutes' drive of the patient, he should be immediately removed thereto and cold-sponged in transit and while awaiting transport. If the cooled ward is at a distance, an emergency cold room should be available, attached to the local ice-plant, where the patient can have immediate treatment; he should then be transported to the cooled ward by a fast ambulance in the coolest part of the night (Marsh, 1930). If the patient is in a tent, away from civilization, he should be stripped and laid on a webbing mattress and wrapped in a sheet (Hearne, 1919) wetted with the coldest water obtainable, and the surrounding air should be kept in brisk circulation by means of a hand- or power-driven fan.

Further treatment

Whichever method is chosen, or is dictated by circumstances, must be persisted in until the patient's rectal temperature falls to 102° F., and the cooling system must be kept in action until all tendency to relapse has ceased, or until the patient can be admitted to a properly cooled ward. As soon as the patient is out of danger of immediate death from heat-stroke, he should drink one or two pints of 0.25 per cent saline, to which may be added 0.1 per cent potassium bicarbonate to assist in the neutralization of the lactic acid in the blood. The saline bicarbonate mixture (double strength) may be administered per rectum by the continuous drip method. If marked dehydration is a feature of the case, it may be necessary to administer sterile normal or hypertonic saline by the intravenous route; it is rarely advisable to administer bicarbonate intravenously, because the process of sterilization may convert some bicarbonate into harmful carbonate. Severely dechlorinated patients may have to ingest 1 to 2 ounces of powdered sodium chloride a day in addition to other measures (Marsh, 1933).

*Salines**Prevention of relapse*

When the patient is homeothermal, rational, and imbibing saline, further treatment must be directed to the prevention of relapses and to dealing with any associated condition which has come to light in the

course of the diagnostic investigation. If the patient remains comatose in spite of cooling treatment, further treatment will depend on the results of the diagnostic investigation, which must be pressed with all the resources at the disposal of the pathological and medical departments; the chances of the patient's recovery will depend on what measure of success attends their efforts.

The patient admitted with mild, severe, or simulated heat-exhaustion is carefully investigated, as indicated above, and is then treated by salines, salt powder, rest, environmental coolness, the intramuscular injection of coramine 1 to 5 c.c., and remedies for constipation; any associated malady should be diagnosed and treated appropriately. When the patient admitted with hyperthermia or some grade of heat-exhaustion is feeling well, has a normal blood-pressure, over three grams of sodium chloride in his twenty-four hour specimen of urine, and a consistently normal temperature, pulse and respiration rates, and any associated condition has been successfully dealt with, preparations for returning him to his hot environment can be made. He should be impressed with the principles of domestic and personal hygiene already described and should be gradually allowed out of the cooled ward, at first to sleep only, then for gradually lengthening periods during the day; he may then be allowed to go home without work for a few days or a week, then to work half-time for a few days or a week, and finally to resume his usual employment. He should be kept under careful observation by the welfare department until the end of the hot season.

*Treatment
of heat-
exhaustion*

*After-
treatment*

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HEMIANOPIA

See VISION: SYMPTOMATIC DISTURBANCES

HEMIATROPHY AND HEMIHYPERTROPHY

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Reference may also be made to the following titles:

ANEURYSM	BONE DISEASES
BIRTH PALSIES	HEMIPLEGIA
SYMPATHETIC AND PARA-SYMPATHETIC NERVOUS SYSTEM DISEASES	

1.—DEFINITION

662.] Atrophy and hypertrophy ordinarily imply progressive change towards diminution and increase of size respectively. Likewise the prefix *hemi-* is usually applied to the whole of one side of the body. In the diseases to be considered so precise a meaning has not been kept. Each word is used to describe what is merely a static asymmetry in which there is not any real atrophy or hypertrophy, and the prefix is applied indiscriminately to cases in which one entire half or only a part of the body is involved. It is true that the affected part may be named, e.g. facial hemiatrophy and hemihypertrophy of the leg, but agreement as to the extent of the lesion which justifies the prefix has not yet been reached.

2.—ACQUIRED HEMIATROPHY

663.] Apart from the rare cases of arteriovenous aneurysm of the main vessels of a limb (see Vol. I, p. 535) there is not any acquired lesion which leads to local hypertrophy nor any which causes total hemihypertrophy. The conditions in this group which remain for discussion are therefore all of the nature of atrophy. Some are progressive, at least for a time, and the others are associated with obvious disease of the central nervous system. In both these respects they are in marked contrast with so-called congenital hemihypertrophy (see p. 421).

(1)—Partial Hemiatrophy (Parry-Romberg's Syndrome)

(a) *Definition*

Progressive facial hemiatrophy is a remarkable and not very uncommon condition in which one half of the face is gradually diminished in size. It was first recognized by Parry (1825) and later more fully described by Romberg (1846). In 1932 Archambault and Fromm published an excellent review of the subject, calculating then that 'the total number of reported cases of facial hemiatrophy easily reaches the figure of 400 and probably exceeds it'.

*Progressive
facial
hemiatrophy*

(b) *Aetiology*

Facial hemiatrophy is usually a disease of early life and affects the sexes about equally. No age group is exempt, and there is no familial or congenital incidence. A history of trauma has been obtained in about one-quarter of the published cases. Often this trauma is relatively slight, but it usually precedes the observed wasting by a few weeks only. Its relation to the disease remains uncertain. Among many suggested causes a lesion of the sympathetic system seems the most probable. Horner's syndrome or paralysis of the cervical part of this system is often present. The eyelid is moderately drooped, the palpebral fissure is smaller, and the eyeball is slightly sunken in the

Incidence

Trauma

*Sympathetic
system*

*Horner's
syndrome*

orbit. The pupil is diminished in size and fails to dilate when shaded or when the skin of the neck is pinched, although it contracts naturally with light. The skin of the face is paler and cooler and sweats less than on the normal side, except in recent palsies, when it may be redder and warmer. Occasionally the disease has seemed to follow interference with the sympathetic system in the neck, but in some cases the function of the trigeminal or of the facial nerve is undoubtedly impaired.

The argument that facial hemiatrophy has not yet been reported as a sequel of cervical ganglionectomy is not as valid as it may seem, because the sympathetic accompaniments do not suggest simple ablation of function, but rather a mixed lesion of an irritative and destructive kind. The occasional spread of the atrophy to the neck, arm, and upper chest of the same side is still consistent with the anatomical areas of supply of the cervical sympathetic.

Not altogether unconvincing attempts have been made to connect the much rarer cases of gradual involvement of the whole of one side of the body with a lesion of the central sympathetic pathway in the hind- and mid-brains. This view, held chiefly by French authors, would also account for the few instances of facial hemiatrophy occurring in syringomyelia and other diseases of the cerebrospinal axis (see SPINAL CORD DISEASES).

Cerebrospinal lesions

So far as disease of the cervical sympathetic system may be held responsible, the association of pulmonary tuberculosis with facial hemiatrophy is interesting. Archambault and Fromm were unable to collect more than three cases in which a necropsy had been carried out; in all of these there was extensive tuberculous disease of the lungs, and in two the cervical glands were similarly affected. Earlier writers laid stress on the frequency of tuberculosis either in the apices of the lungs or in the cervical glands, but this point seems to have been almost forgotten in more recent literature. The ease with which the cervical sympathetic might be attacked in such cases is obvious. In a fourth necropsy the superior and inferior cervical ganglia as well as the upper ganglia of the paravertebral sympathetic chain were found to be diseased on the same side as the hemiatrophy (Stief).

Pulmonary tuberculosis

It is also held that facial hemiatrophy may follow acute infective diseases and local infections of the face and mouth. As an example of the incidence of hemiatrophy following a general infection Sterling's case, which was a sequel to encephalitis epidemica, is of interest, as it suggests a central origin for the atrophy. Injury has already been mentioned as a predisposing factor, and most of the cases in which oral sepsis has been held responsible are found to have been exposed to surgical trauma. Even in the accidental cases it is unusual for the injury to have been more than trifling.

Acute infective diseases

Oral sepsis

Attempts have been made to suggest a common origin for scleroderma and progressive facial hemiatrophy; but, although the skin may be thinned and hardened locally in the latter, these cutaneous changes are never found beyond the area of atrophy.

Because the site of the atrophy is within the territory of the trigeminal nerve, some authors have tried to relate the disease to pathological disturbances in the nerve or its connexions. This 'trigeminal' hypothesis rests chiefly on the presence of a proliferative interstitial neuritis in the peripheral branches of the fifth nerve in two of the four cases examined microscopically, but it is also supported clinically by uncommon cases of facial hemiatrophy with sensory impairment and even neuroparalytic keratitis (see Vol. III, p. 429). Neuralgic pain occurs in a proportion of these patients, but it is often not limited to the trigeminal area and is never of the paroxysmal *tic douloureux* type (see NEURALGIA, GLOSSOPHARYNGEAL AND TRIGEMINAL). Many of the atypical facial neuralgias do not depend upon trigeminal disease, and it would be rash indeed to imagine that local pain in facial hemiatrophy necessarily suggested a lesion of the fifth nerve. This hypothesis fails to account for those cases in which the atrophy spreads into the neck, arm, and chest, and less still for those in which a complete unilateral atrophy ultimately develops.

'Trigeminal' hypothesis

Neuralgia

(c) Clinical Picture

The wasting may begin in any part of the face and spreads slowly or rapidly to involve the whole of that side, usually producing serious

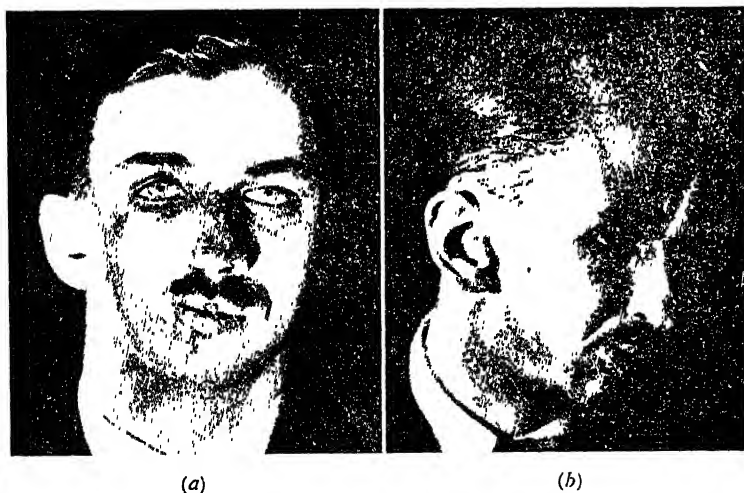


FIG. 62.—Extreme and generalized facial hemiatrophy. (a) Showing definite line of cleavage and pigmented areas over the mandibulo-cervical region; (b) showing band-like zone of alopecia, cleft in the mid-line of the forehead, and more easily recognizable pigmentation on affected side. (From *Archives of Neurology and Psychiatry*, Chicago, 1932)

disfigurement (see Fig. 62). All structures—skin, subcutaneous tissue, muscle, and bone—are ultimately involved, but it is remarkable that the reduction of muscle bulk takes place chiefly at the expense of the contained fat and connective tissue. Neither the power nor the electrical

reaction of the muscles is demonstrably changed. The degree of bony atrophy varies with the age at onset, being greater the earlier the disease started. Often the muscles of the tongue, jaws, and pharynx share in the wasting. Certain associated changes are commonly but not invariably found in the affected areas, the most notable being Horner's syndrome (see p. 417), alopecia, sclerodermia, and pigmentary changes in the hair, skin, and iris.

(d) *Course and Prognosis*

There is not any known method of arresting the process once it has begun, but it may cease spontaneously at any stage. This rarely happens before the patient's appearance has become so changed that the halves of his face seem to belong to two different persons. Occasionally the atrophy spreads beyond the face to the neck, chest, and arm, or even to the whole of the same half of the body. Archambault and Fromm (1932) stated that about twenty-three cases of total progressive hemiatrophy had been recorded.

Spread

(e) *Diagnosis and Differential Diagnosis*

In its established form the appearances of progressive facial atrophy are characteristic and cannot be confused with any other disease. In a case seen for the first time at an early stage it is necessary to distinguish marked facial asymmetry of a congenital kind or resulting from a torticollis which has been present from youth. Such asymmetry, however, is never accompanied by the changes in the skin and subcutaneous tissues with the deep furrowing seen in progressive facial hemiatrophy.

*Diagnosis
from
torticollis*

(f) *Treatment*

Its ill defined relation to sclerodermia and the fact that the cervical sympathetic has shown morbid changes in the few recorded necropsies have suggested to some that benefit may result from the removal of the sympathetic nerve-supply to the affected area. Surgery is also useful for cosmetic repair when the atrophy has ceased spontaneously. The older authorities advised the injection of melted paraffin, but this is not free from risk and is seldom satisfactory. Plastic surgery has met with more success.

*Sympath-
ectomy*

*Cosmetic
repair*

(2)—**Total Hemiatrophy**

Apart from the rare cases of progressive facial hemiatrophy which involve the whole of one side of the body, total hemiatrophy of a kind may follow damage to the central nervous pathways. When this occurs at an early age, imperfect development of the affected side of the body often results. The commonest clinical example of this is infantile hemiplegia, in which the whole of one side of the body in severe cases or merely the affected hand and foot are slightly but measurably smaller than the corresponding normal parts (see Vol. II, p. 340).

*Progressive
facial
hemiatrophy*

*Infantile
hemiplegia*

Lesions in the parietal cortex or subcortical region of the brain some-

times produce a remarkable flaccid paralysis of all the muscles of the opposite half of the body as well as the better known sensory changes. *Cortical lesions*
In such cases the weak muscles may also be so much wasted as to suggest involvement of the lower motor neurones. Probably this is the only instance of true total muscular hemiatrophy, used in a precise neurological sense. A good review of this rare cause of hemiatrophy was given in 1935 by Winkelman and Silverstein.

3.—CONGENITAL ASYMMETRY

(1)—Definition

664.] Congenital hemihypertrophy and, less often, congenital hemiatrophy are terms used to describe what is really a static inequality of the two sides of the body. In a person so affected sufficient asymmetry is present to attract attention. If he happens to be generally undersized, attention tends to be focused on the smaller half of the body, which is described as being affected by congenital hemiatrophy. It would be equally true to describe his larger half as showing hemihypertrophy, and this is more usual. Whichever descriptive term is used, the condition is essentially an asymmetry, and neither hypertrophy nor atrophy is strictly applicable to it. The two sides of the body are unequal from a very early stage of intra-uterine life; in spite of this, development proceeds smoothly and normally, with the result that the relative disproportion remains constant. Such asymmetry may be only partial, affecting only one extremity or even a part of a limb; occasional cases of crossed hemihypertrophy have been reported.

(2)—Aetiology

The most instructive articles on the subject have been written by Gesell, who in 1921 collected 39 recorded cases of total congenital hemihypertrophy, adding one of his own. In a second paper published in 1927 he brought the number of reported cases up to 53. Wakefield and Hines (1933) estimated that about 80 cases had been recorded up to that time, and Peabody in 1936 found a total of nearly 100 cases. It is thus an uncommon condition, at least in a degree which brings it under medical observation. *Incidence*

Although the asymmetry may not be noticed until the child is able to walk, it is certain that it is always congenital. There is no convincing evidence of any familial or hereditary factor, although Scott recorded instances of hemihypertrophy in a mother and a daughter. These appear to be the only cases with such a relationship. In Gesell's review (1921) of 40 cases, females were affected rather more than males, and the right side of the body was the larger in about 70 per cent. Half the patients had telangiectases, naevi, and other cutaneous abnormalities, and 13 per cent presented various grades of mental deficiency. Later publica- *Associated defects*
tions do not support the idea that one sex or one side of the body is

particularly affected, but there is no doubt that congenital anomalies are found in a higher incidence than would occur in a group of persons picked at random.

*Mental
deficiency*

Gesell (1921) gave special prominence to the occurrence of mental deficiency in these patients and quoted Greig's opinion that the asymmetry might be caused by an early intra-uterine inflammation of the cerebrospinal axis. He agreed that this hypothesis was doubtful, but later he seemed to return to it to account for the high incidence of feeble-minded patients. More probably the occurrence of mental deficiency and of cutaneous naevi with hemihypertrophy can be explained simply on the grounds that the subject of one congenital anomaly is often found to have others when carefully examined.

*Incomplete
twinning*

The cause of this remarkable condition still remains unproved, but Gesell's suggestion that it represented an incomplete minimal form of twinning seems nearest the truth. 'Since we do not know the true cause of hemihypertrophy, there is no dearth of etiologic theories. These "explanations" range from maternal impressions to internal secretions. A German mother ascribed the hemihypertrophy in her son to the fact that during pregnancy she had seen a youth of gigantic proportions in the market place. Presumably she saw only one side of this giant' (Gesell, 1921).

*Hypothesis
of pituitary
overactivity*

The idea that hemihypertrophy can possibly depend upon overactivity of the pituitary or of some other endocrine gland is scarcely less ridiculous than this example of lay superstition. Any growth-controlling factor which is distributed through the general blood-supply cannot conceivably affect one part of the body more than another. That the vessels of the hypertrophic side of the body or of the opposite side of the brain provide a fuller blood-supply is not proved by fact and in any case merely shifts the search for the cause one stage further back.

Besides such general growth-factors as the internal secretions, vitamins, and other food-elements, the activities of which in post-natal life have been well established, there must be other 'internal determiners' (Gesell) which are already laid down in the fertilized ovum. Many biologists regard size as a unit character of inheritance subject to Mendelian principles. According to the fusion theory put forward by Marchand and Ziegler two distinct anlagen may be present within a single ovum. These may develop independently to produce twins or, fusing very early, lead to the formation of a double monster. Possibly a more perfect early fusion might result in the development of an asymmetrical (hemihypertrophic) individual, each half of whose body might reasonably be regarded as belonging to a separate twin. Although the actual embryonic mechanism of symmetry-regulation is uncertain, the suggestion that congenital hemihypertrophy should be interpreted as an atypical or imperfect form of twinning seems better than any other hypothesis to explain the condition.

In support of this belief Gesell also recalled the remarkable differences

in output of energy, as distinct from mere physical disparity, of the two sides of the body. On the larger side the body-temperature has often been found to be higher and the teeth may appear earlier and the hair and nails grow more vigorously. *Physical differences*

(3)—Morbid Anatomy

The asymmetry probably affects all the tissues, although 'in those cases which have come to necropsy the histologic study of the hypertrophied organs shows that the increase in bulk is due chiefly to an overgrowth of connective tissue' (Gesell, 1921). Several more recent authors have proved radiographically that the bones at any rate are longer and thicker on the side of the hypertrophy. There are not any changes in the density of the bones nor any other evidence that they are not perfectly normal.

(4)—Clinical Picture

A few of the reported cases have been noticed at birth, the limbs, the ear, and the face of one side being obviously bigger than on the opposite side. Many cases have not attracted attention until the child begins to walk (see Fig. 63), when the asymmetry is shown by an obvious limp. In some of the milder cases, particularly those in which only one limb is affected, the asymmetry is not observed at all by the patient or his relatives until it is brought into prominence by some chance accident.

The patient may seek medical advice on account of other congenital anomalies, and hemihypertrophy may then be discovered for the first time. This point should be borne in mind in the examination of any person found to have some congenital defect, particularly in cases of unexplained mental deficiency. Muscular power on the larger side is either not increased at all or so little as to be negligible. Sensory, motor, and reflex functions of the nervous system are normal on both sides.

The commonest associated congenital anomaly is in the cutaneous blood-vessels, multiple telangiectases and extensive naevi of the 'port-wine stain' type being often present. These are not particularly related to one side of the body. Cryptorchidism, hypospadias, polydactylism, and congenital heart disease have also been recorded. Mental deficiency of all grades to complete idiocy has been found. *Associated anomalies*

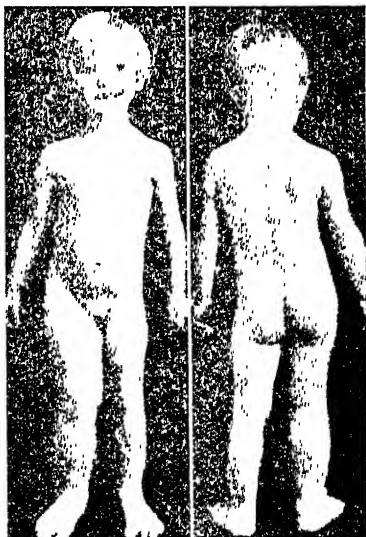


FIG. 63.—Hemiatrophy of right upper and lower extremities.

(From *American Journal of Diseases of Children*, 1933)

Symptoms

As the two asymmetrical halves of the body are normal in every other particular, symptoms are not noticed in the milder grades. If there is much difference between the lengths of the legs, however, orthopaedic problems will arise.

(5)—Course and Prognosis

The two sides of the body keep the same degree of disproportion throughout life, at least after the cessation of active skeletal growth. Complications are not to be expected other than those relating to the compensatory scoliosis which usually develops.

(6)—Diagnosis and Differential Diagnosis

In a well marked case of congenital hemihypertrophy in which the condition is known to have been present from birth the diagnosis does not present any difficulties; it can be made from the striking asymmetry of the two sides of the body without signs of organic disease of the nervous system. In the milder degrees of asymmetry, particularly if it is not total and it is discovered for the first time later in life, the diagnosis may not be so clear. A neurological examination should exclude hemiplegia, and the absence of real atrophy of the skin and deeper tissues will show that the case is not one of the rare instances of Parry-Romberg's syndrome (see p. 417) which has become total. In the partial hemihypertrophies congenital arteriovenous communication leading to true hypertrophy of the limb and local conditions obstructing the venous or lymphatic return have to be considered (see PHILARIASIS, Vol. V, p. 301, and LYMPHATIC VESSELS DISEASES). Marked reddening and increase of warmth, often with dilated and tortuous surface vessels, declare the former condition, and oedema, which pits on pressure or at least disappears when the limb is elevated, quickly distinguishes the latter. It is said that Milroy's disease, hereditary oedema of the lower extremities, may be asymmetrical in its earlier stages and yet sufficiently widespread for it to be confused with partial congenital hemihypertrophy. Such cases must be extremely rare, but the family history and the presence of oedema in the tissues of the enlarged limb will make the diagnosis plain.

*Diagnosis
from acquired
hypertrophy*

*From
Milroy's
disease*

(7)—Treatment

It is only for the defect of posture necessarily associated with the severer grades that congenital hemihypertrophy either demands or is amenable to treatment. The difference in the lengths of the legs results in a tilting of the pelvis and in a compensatory scoliosis (see SPINE, DISEASES AND DEFORMITIES), which in its turn may be a fruitful source of simple backache, vertebral arthritis, or sciatic neuritis. The development of such complications is easily prevented by simple orthopaedic measures, such as a boot with a thickened sole, whereby the lengths of the lower extremities are again made equal.

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HEMIPLEGIA

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Reference may also be made to the following titles:

APHASIA	BRAIN: REGIONAL DIAGNOSIS
APOPLEXY	SPINAL CORD DISEASES

1.—DEFINITION

665.] The word hemiplegia is applied to the impairment of voluntary movement of one side of the body which results from damage of the pyramidal tract or of that part of the opposite cerebral cortex in which voluntary movements are initiated. Such damage is rarely confined strictly to the pyramidal tract or to the excitable motor cortex, so that besides this impairment of voluntary movements there are usually other disturbances of function, e.g. an alteration in the resistance to passive

movements of the limbs affected, spasticity or flaccidity, and a change in the tendon and superficial reflexes on the same side of the body. For this reason several types of hemiplegia are commonly described, a flaccid or a spastic hemiplegia, capsular or carotid hemiplegia, in cases in which the site of the lesion is clearly indicated by these associated disturbances of function. It is, however, to the disturbance of voluntary movements alone that the term hemiplegia is properly applied.

*Associated
disturbances
Types*

2.—DISTRIBUTION OF MOTOR IMPAIRMENT

Complete loss of voluntary movements on one side of the body, involving the face and trunk and both limbs on that side, is found only for a short while, at the most a few days, after the onset of extensive damage to the pyramidal system. In all other cases the hemiplegia is incomplete, and in most cases one of these parts of the body is found to be more severely affected than are the others. This unevenness in the distribution of the symptoms results either (i) from the fact that some parts of the body recover earlier and more completely their ability to move under voluntary control or (ii) from the fact that the actual structural changes are less severe and less disabling in one part of the pyramidal apparatus than in another.

Complete

Incomplete

When, in the latter event, the damage is so strictly confined that functional impairment is found only in the leg or in the arm, it is usual to describe this as a crural or a brachial monoplegia. Since the pyramidal tract is formed of neurones which originate in a comparatively extensive part of the cerebral cortex, converge to form a comparatively compact bundle in the internal capsule, and remain thereafter grouped together in this way until they reach their destinations at different levels of the spinal cord, a hemiplegia which remains persistently uniform in its distribution must result from a lesion at or a little below the internal capsule, whereas one which is from the outset conspicuously uneven or monoplegic in its distribution indicates damage of, or immediately subjacent to, the cerebral motor cortex.

Monoplegia

Site of lesion

With only slight variations, which will be discussed later, this difference in the distribution of the motor impairment, which is determined by a difference in the level of the lesion, does not affect the nature of the disturbance of voluntary movement, which is characteristic of all hemiplegias, whether complete or incomplete.

3.—NATURE OF MOTOR IMPAIRMENT

Upon those lowest level centres, distributed between the mid-brain and the sacral region of the spinal cord, through which all muscular activity is brought about, there converge controlling pathways from several different levels of the central nervous system. Besides the pyramidal

Anatomy

tract there are those which arrive from the striatal motor system governing the maintenance and the changes of postural activity, those which mediate cerebellar and vestibular control over phasic motor changes, and those which provide purely local or segmental reflexes.

Associated phenomena

Damage of the pyramidal tract alone, leaving these other influences intact, very rarely occurs: in nearly all cases there is an associated exaggeration or 'release' of these other motor systems which compete for control over the lowest level mechanism, and the final disability which results is only in part due to an inability to initiate or to transmit the appropriate nervous impulses by way of the pyramidal tract.

Movements affected

The result is that the disturbance is not entirely confined to voluntary or intended movements, although it is invariably greatest in respect of those movements which call for attention and for precision, are the skilled result of frequent practice demanding this attention, and have a 'significance' which is intellectual rather than affective. These differences are seen not only in the degree to which the movements of any one part of the body are limited in a given case but also in the rate of recovery of different forms of movement after their initial loss.

*Complete hemiplegia
Immediate effects*

A complete hemiplegia provides the following disturbance of movement. Immediately after its onset, while consciousness is still lost, the eyes and the head may be found turned strongly away from the side on which the hemiplegia is later observed. After consciousness has been recovered, conjugate deviation of the eyes towards the side of the hemiplegia may be difficult to initiate, restricted in range, and poorly maintained. This disturbance, together with some weakness of rotation of the head towards the hemiplegic side, rarely lasts for more than a few days.

Face

At first there may be almost complete absence of movement on one side of the face; movements carried out with the upper part of the face reappear first, e.g. corrugation and elevation of the eyebrows and closure of the eyelids; movements of the lower part of the face are later in reappearing and slower in their recovery. The asymmetry is greater for unusual movements made on request than for expressional movements, with the result that retraction of the angle of the mouth is more prompt and more extensive in smiling or weeping or in the associated change of facial expression which accompanies strong effort than it is in mimicking a grimace. As recovery proceeds, these differences may disappear, leaving only some persistent slowness of movement on one side of the mouth and imperfect burying of the eyelashes when the eyes are screwed up.

Jaw, palate, and tongue

Initially there may be some weakness of the jaw musculature, shown by a deviation of the mandible towards the hemiplegic side when it is forcibly depressed against resistance. The palatal arch may hang lower on the hemiplegic side and the uvula be drawn up towards the other side on phonation. The tongue, although lying symmetrically in the floor of the mouth when retracted, may be protruded towards the hemiplegic side owing to a unilateral defect of movement. These

asymmetrical movements of the jaw, palate, and tongue are very rarely more than slight and transitory.

Immediately after the onset of hemiplegia the loss of voluntary movements in the arm and leg may be complete. The rate at which recovery proceeds and the level of disability which is finally attained vary widely from patient to patient, but in all patients voluntary control is re-established in much the same way, except when an initial hemiplegia masks a defect which is essentially monoplegic in distribution. *Limbs*

Movement at the proximal joints of the limbs reappears first, with the result that in the leg the flexed thigh can be extended and the abducted thigh can be drawn towards its fellow before any movement at the knee or ankle is evident. Later, voluntary flexion of the thigh, extension and flexion of the knee, and plantar flexion and dorsiflexion at the ankle reappear usually in that order. Flexion and extension of the toes may return with corresponding movements at the ankle, but they are often further delayed: they usually remain slow and weak in execution, and independent movements of the toes are commonly the last form of voluntary movement in the leg to appear and may remain persistently absent, even when functional recovery elsewhere in the leg is excellent. *Leg*

In the arm elevation and depression of the shoulder and adduction, extension, and flexion of the upper arm are movements which usually reappear early. Abduction of the upper arm is often delayed until flexion and extension at the elbow have reappeared. Flexion of the wrist and simultaneous flexion of all the fingers appear soon after. Extension of the wrist and pronation and then supination of the elbow are often later in returning, and voluntary extension of the fingers is still further delayed. As recovery proceeds, the ability to flex and then to extend the fingers separately returns, and these independent movements of the fingers, at first hesitant, clumsy, and much delayed in their initiation, become prompt and precise. *Arm*

In respect of both the arm and the leg it is found that movements which cannot be carried out at will as isolated acts may appear readily and in good force as part of a more extensive movement complex: thus in the leg voluntary dorsiflexion of the ankle alone may be impossible, and yet, when active flexion at the knee and hip is carried out, quite strong dorsiflexion at the ankle also may simultaneously appear. In the same way flexion or extension of the toes may be impossible in isolation and yet be both prompt and powerful in combination with plantar and dorsiflexion of the ankle respectively. *Arm and leg*

In the arm, at a stage in which flexion of the wrist and flexion of the fingers are hesitant and weak, these movements may appear in good force as an accompaniment of active flexion of the elbow; and, when a solid object is placed in the palm, all the fingers and the thumb may become strongly flexed in an active effort of grasping at a stage in which these movements are of poor and uncertain execution as isolated acts. Highly skilled movement sequences, such as are entailed in the

reproduction of a manual technique acquired by long practice, e.g. piano playing, never recover fully, except when the initial hemiplegia has been both slight and transitory.

*Abdominal
wall and
chest*

It is difficult to judge how far movements of the abdominal wall and of the chest are disturbed in hemiplegia. Displacement of the umbilicus away from the hemiplegic side when the rectus abdominus muscle is strongly contracted is a fairly common observation at an early stage of recovery from a severe hemiplegia. Recently published records suggest that a difference in the excursion of the chest on the two sides could invariably be found if specially looked for; but this difference seems more closely related to the states of flaccidity or of spasticity which accompany most hemiplegias than to the actual loss of voluntary control.

4.—ASSOCIATED SYMPTOMS

*Capsular
lesions*

Destruction of motor pathways in the internal capsule results in an alteration of muscular activity on the opposite side of the body, which is not confined to a hemiplegia in the above restricted sense of an impairment of voluntary movement. There is also a change in the resistance to passive movement of the limbs on the affected side, a change in the tendon-reflexes in those limbs, a tendency for the limbs to adopt certain stereotyped postures, and a change in the superficial reflexes which can be elicited from the same side of the body.

Reflexes

For a variable period after the occurrence of an acute capsular lesion the limbs are flaccid, and their tendon-reflexes and the abdominal and plantar reflexes are usually absent. This period of flaccidity and absent reflexes may last for a few hours or, more rarely, for one or two days. It is followed by a state of spasticity in the musculature of the hemiplegic side, with exaggeration of the tendon-reflexes and the appearance of an extensor plantar response. The abdominal reflexes may remain absent or may reappear in a weakened form. A capsular hemiplegia invariably shows these changes to a well marked degree. When the same impairment of voluntary movements is due to damage of the cerebral cortex, the resulting monoplegia is often accompanied by the same changes, but this is not invariably the case, and, whereas in a capsular hemiplegia the degree of voluntary decontrol and the degree of spasticity are usually proportionate, this is not true in respect of a cortical monoplegia.

*Capsular and
cortical
lesions
compared*

*Cortical
lesions*

A small area of destruction, confined strictly to the precentral convolution and not involving neighbouring parts of the cortex, may result in impairment of voluntary control over the movement of one part of the body on the opposite side, without any spasticity or increase of the tendon reflexes, i.e. a flaccid monoplegia.

It has also been suggested (Fulton) that a lesion similarly confined to a part of the frontal lobe immediately in front of the precentral convolution results in a severely disabling spasticity of the opposite limbs,

which contributes more towards impairment of function than does the actual defect of voluntary control which is always also in a minor degree present.

From a study of such naturally occurring lesions and of similar lesions experimentally produced there has emerged the following conception of the nature of the functional disturbance in such cases. *Subcortical 'release' in hemiplegia*

The part of the cerebral cortex immediately in front of the precentral convolution is concerned not only with the patterning and the initiation of impulses destined to produce voluntary (phasic) changes in the state of activity of the lower motor neurones but also with such changes in the activity of other motor centres as are essential for the unimpaired execution of these voluntary movements.

Thus, since every voluntary movement necessarily involves a disturbance of posture, the influence of those lower level mechanisms, striatal and vestibular, which subserve the maintenance of posture must be kept in abeyance during the execution of a voluntary movement and reimposed after its completion. Similarly, the segmental reflexes must be rendered responsive to those modifications of their activity through which the voluntary or phasic changes in the state of muscular contraction are brought about.

These changes are mediated through connexions between the premotor part of the cerebral cortex and the corpus striatum, the vestibular centres and the formatio reticularis. The result of destruction of this part of the cortex may be expressed as a release from control of these lower level mechanisms; postural activity becomes persistently increased and is no longer modified in accordance with the requirements of voluntary movement, and the segmental reflexes become increased both in the facility with which they can be elicited and in the vigour of the resultant response.

Two other forms of motor disturbance also occasionally appear, i.e. *Less common associated disturbances* involuntary movements unrelated to voluntary activity and an exaggeration of the associated muscular contraction accompanying voluntary movement. In a capsular hemiplegia these additional symptoms appear presumably as the result of interruption of neurones other than those of the pyramidal tract and which descend from the premotor cortex to make independent connexion with lower level mechanisms in the brain and in the spinal cord.

5.—HEMIPLEGIC SPASTICITY

In the affected limbs the muscles become persistently contracted, with the result that they are firmer to the grasp. Greater force is necessary to bring about passive movements of the limb segments not only because of this pre-existent state of increased tension in the muscles but also because stretching of any of the muscles elicits reflexly in that muscle a state of still further increased tension.

This increase of persistent or of reflexly elicited contractions, however, *Distribution*

is not uniformly distributed throughout the muscles of a given limb: in the arm it is predominantly in the adductors and internal rotators of the shoulder and in the flexors of the elbow, wrist, and digits; in the leg it is found chiefly in the extensors of the hip and knee, the calf muscles, and the flexors of the toes. As the direct result of this selective incidence of increased postural and segmental motor activity the arm becomes drawn up with the flexed forearm lying in front of the chest and with the wrist and fingers fully flexed; and when released after passive or active displacement it returns shortly to this position. In a similar way the leg takes up a position of full extension at all joints, with the result that in walking it must be swung round or circumducted in order that the toes shall clear the ground.

Stretch-reflexes

This state of spastic contraction may become so highly developed that passive extension of the arm or passive flexion of the leg is no longer possible. In every case more force is required to extend the arm or to flex the leg than is necessary for movements in the reverse direction. Further, the reflexes which are exaggerated in their activity provide a clear expression of the lengthening and shortening components of the stretch-reflexes of experimental physiology. It is found that, when an attempt is made passively to extend the flexed forearm, the force applied has to be progressively increased up to a point at which the hitherto increasing resistance of the stretched muscles suddenly subsides, the muscles yield under the passive stretch, the force required to produce further extension becomes much less, and movement is completed with little difficulty. This phenomenon is called clasp-knife rigidity and is one of the characteristics of the spasticity which accompanies the hemiplegic state both in the arm and in the leg.

Clasp-knife rigidity

Permanent contractures

As a consequence of lasting spasticity non-contractile components of the habitually contracted muscles may shorten, and those of the habitually extended muscles may lengthen, with the result that a permanent contracture may develop and the range of passive movement become restricted by structural changes which only surgical division can remedy. In any case the state of spasticity greatly hampers the freedom of movements which would otherwise be well carried out as voluntary control returns. It is only in the limbs that spasticity is easy to detect, but palpation of the abdominal wall may reveal a relative increase of the firmness of the musculature on the hemiplegic side.

Tendon-reflexes

In the limbs of a spastic hemiplegiac the tendon-reflexes are increased, although occasionally the spasticity may be so great that this increase is difficult to demonstrate. Individual reflexes can be elicited with a lighter blow, and the resulting contraction is more vigorous. Muscles from which stretch-reflexes cannot be in this way normally elicited yield in the hemiplegic state facile responses, with the result that to the biceps-, triceps-, and supinator-jerks there are added tendon-reflexes from every muscle of the arm, the sudden stretch of which is practicable, and a blow over the coracoid process produces a convulsive flexion of the whole limb.

In the leg exaggeration of knee- and ankle-jerks, vigorous hamstring-jerks, and adductor-jerks can all be elicited with increased facility. A clonic response is often found; in the leg, by sudden depression of the patella or sudden dorsi-flexion of the ankle, knee- and ankle-clonus respectively and in the arm clonic responses from the finger and wrist flexors and even from the biceps can sometimes be obtained.

One of the earliest reflexes to reappear after the initial total eclipse which follows the onset of severe hemiplegia is the flexion reflex in the leg; this is seen earliest as an upward movement of the great toe which follows a scratch applied to the outer side of the sole of the foot (Babinski's extensor plantar response). In the course of the few days or weeks following its first appearance this reflex becomes increased in facility and more extensive in its expression. Although it remains most easily elicited by the above stimulus, pinching, pricking, or scratching any part of the foot or lower part of the leg comes to yield a response. To extension of the great toe is added abduction or fanning of the other toes, flexion of the knee, dorsi-flexion of the ankle, and, later, flexion of the hip, with the result that in its fullest expression the leg is promptly withdrawn from the source of stimulation.

*Reappearance
of reflexes*

*Babinski's
extensor
plantar
response*

*Accompani-
ments of
extensor
response*

The abdominal and the cremasteric reflexes on the side of the hemiplegic impairment are diminished or lost. This diminution may show itself as a difficulty in eliciting any response or as a premature fatigue of the response on repeated stimulation. The exact structural alterations in the nervous system which are essential for the production of these changes in the abdominal responses are uncertain; the changes almost invariably occur with a capsular hemiplegia but sometimes are absent in a partial hemiplegia or monoplegia of cortical origin.

Hemiplegic limbs which are severely spastic and over which there is little or no voluntary control occasionally move quite freely under the influence of involuntary factors; the patient may find that in yawning or in stretching on awakening from sleep his arm, which at all other times is firmly contracted in full flexion, may participate in these movements by becoming strongly extended at the elbow with partial relaxation of the wrist and finger flexion. Simultaneously the leg may exhibit a powerful and often a tremulously clonic extension.

*Involuntary
movement*

The postural influences which determine these lasting positions of the arm and leg may also be modified, with the result that changes in the degree of spastic contraction are brought about reflexly. Thus, if the head and neck are turned fully towards the hemiplegic side and the patient simultaneously makes a maximal effort of some kind, e.g. grasping, with the sound arm, the hemiplegically contracted arm may slowly extend at the elbow and abduct slightly at the shoulder. A repetition of his effort at grasping with the head maximally turned away from the hemiplegic side may similarly result in stronger flexion of the elbow and further adduction of the arm. During these procedures similar changes in the posture of the hemiplegic leg may be observed.

*Postural
influences*

In children damage of the cerebral cortex is more apt than in adults

Effects in children

to result in a disability which is completely hemiplegic and not monoplegic, and in children also the later stages of recovery are apt to be disturbed by the appearance of involuntary movements, athetotic or choreic in form, which are comparatively seldom observed after the hemiplegias of adult life.

Speech

After any moderately severe hemiplegia there may be a blurring and slowness in the production of speech due to impaired control over the lips, the tongue, and the palate. In a right-handed person hemiplegia affecting the right side is usually accompanied by a disturbance of speech which is exactly similar in its nature to the disturbance of any other series of voluntary movements carried out with the hemiplegic limbs, i.e. there may be complete expressive aphasia at the outset with later partial or complete recovery.

*Aphasia**Recovery of speech*

Common everyday phrases of greeting are usually the first to return. When the patient becomes able once more to converse in the ordinary way, it is found that his choice of words is hesitant and unreliable, his vocabulary is very much restricted, and he does not differentiate well between words of closely related meaning. Under the influence of some emotional stress he may become comparatively fluent, but in contrast with this 'interjectional' use of speech his powers of discussion and of description, the propositional use, remain very much limited. At a stage at which he can construct simple sentences dealing with ideas or objects with which he has been long familiar he may be still at a loss for the name of a common object shown to him, although able to use some periphrasis to show that he identifies it. The more complex and the more recently acquired forms of verbal expression suffer most complete extinction and are recovered last, with the result that a patient of this type may never regain his ability to use a foreign tongue in which he has previously been fluent, although he has completely recovered the use of his native speech.

Secondary disturbances

As the result of a persistent hemiplegia with spasticity the partially paralysed limbs may after a time show secondary disturbances: the circulation in them becomes impaired, with the result that the hand and the foot become cyanotic and cold. If the hemiplegia occurs at an age at which further growth may be anticipated, this becomes slowed down in the affected limbs, with the result that they are outstripped in their growth by those of the unaffected side; their bones may become rarefied and the skin thin and shiny. In some cases a condition of subacute osteoarthritis develops in the joints of the paralysed limbs, with the result that these become rigid and painful on passive movement.

6.—SITE OF THE LESION

(1)—Cerebral Cortex

Destructive changes in the cerebral cortex lead to impairment of movement on the opposite side of the body which is characteristically

monoplegic in its distribution, although when these changes are of sudden onset, as in embolism of the middle cerebral artery, the initial paralysis may be completely hemiplegic. Moreover, with a cortical lesion epileptic attacks, particularly of the focal or Jacksonian type, are often noted. In arterial thrombosis one or more of these attacks often precede the onset of paralysis: a tumour of the cortex may give rise to frequently recurrent convulsive seizures in the opposite limbs followed by transient paralyses for many months before a persistent hemiplegic weakness becomes established. When the left cerebral hemisphere is the site of damage in a right-handed person, an aphasic disturbance of speech of the expressive or motor kind can be expected whenever the hemiplegic weakness involves the face.

*Jacksonian
epilepsy*

Aphasia

(2)—Internal Capsule and Optic Thalamus

Destructive changes in the internal capsule resulting in a hemiplegia almost invariably lead to a disturbance of sensibility on the same side of the body and in many cases also to an homonymous hemianopia in corresponding parts of the visual fields. If the lesion responsible for this damage invades the optic thalamus on the same side, the additional motor symptoms of hemiataxy and hemiathetosis in the weakened limbs may be conspicuous. When the optic thalamus suffers most and the adjacent internal capsule is damaged to a smaller extent, the hemiplegia, initially severe, may later to a large extent clear up and sensory symptoms of thalamic disturbance come to dominate the clinical picture. From the outset there is impaired recognition of painful and of thermal impressions received from the opposite side of the body, but the condition of thalamic hyperalgesia, with spontaneous pains and paraesthesiae of an unpleasant kind and with exaggeration of the affective response to painful stimuli which are sufficiently severe to be elicited at all, usually develops some months afterwards and tends to become more severe as time goes on.

Hemianopia

*Thalamic
syndrome*

(3)—Mid-Brain

A unilateral lesion of the mid-brain below the thalamus may destroy the pyramidal tract in the crus cerebri on one side. The resulting hemiplegia is invariably accompanied by some degree of hemianaesthesia, which in this case affects all forms of sensibility from the opposite side of the body, and often also by other symptoms due to damage of nerve-cells in the mid-brain. Thus damage of the red nucleus may result in the appearance of a slow rhythmic tremor of the hemiplegic limbs and a clumsiness of movement which is out of proportion to their weakness. With this there is usually an ocular motor palsy of nuclear type on the side opposite the hemiplegia—a group of disturbances sometimes described as Benedikt's syndrome. Occasionally these other structures escape, but the third nerve is destroyed, with the result that a hemiplegic weakness on the opposite side of the body is associated with paralysis of the external ocular muscles innervated by the third nerve on the same side (Weber's syndrome).

*Red nucleus
syndrome*

*Benedikt's
syndrome*

*Weber's
syndrome*

(4)—Hind-Brain

In the upper part of the pons the pyramidal fibres which control movements of the face cross to establish connexion with the facial nucleus on the opposite side. Therefore below this level damage confined to one side of the hind-brain leads to a contralateral hemiplegia of the arm and leg without involving the face. The face on the same side as the lesion may be weakened by destruction of the already decussated upper motor neurone or more commonly by damage of the facial nucleus (Millard-Gubler syndrome). The abducens nucleus is often damaged as well, resulting in a weakness or loss of conjugate deviation of the eyes towards the side of the lesion and a paralysis of the external rectus muscle on the same side (Foville's syndrome). In other cases a weakness of the jaw musculature on the same side, an homolateral ataxy of movement due to damage of the inferior cerebellar peduncle, and a contralateral impairment of sensibility, particularly to pain and temperature, due to damage of the ascending sensory tracts, may be added when the lesion is sufficiently extensive to affect these structures.

Millard-Gubler syndrome

Foville's syndrome

(5)—Spinal Cord

Damage confined to one side of the spinal cord in the cervical region above the fifth cervical segment gives a hemiplegic weakness of the contralateral arm and leg on the same side, but there is also an impairment of sensibility to painful and thermal impressions from the opposite side of the body below the level of the lesion due to damage of the crossed spinothalamic tracts.

7.—NATURE OF THE LESION

After an emotional shock or prolonged nervous excitement and sometimes as the result of industrial accidents an hysterical paralysis of hemiplegic distribution may appear. This is usually a flaccid paralysis without any alteration of the tendon or superficial reflexes, but occasionally the arm and leg are held in a state of persistent spasm by a muscular contraction which increases in force when any attempts are made at passive manipulation of the limbs. In some cases there are hysterical hemianæsthesia and other disturbances, such as blindness and deafness, on the same side of the body.

Hysterical hemiplegia

Other kinds of transient hemiplegia
Post-epileptic

In addition to this hysterical hemiplegia there are other kinds of transient hemiplegia which are not associated with any known defects of the pyramidal system. After an epileptic attack with convulsions confined to one side of the body the power of normal movements in these limbs usually returns very soon after consciousness is regained. In some cases, however, a flaccid hemiplegia persists for several hours and is usually associated with loss of the abdominal responses and an extensor plantar response on the same side, although the tendon-reflexes often remain absent. In a few cases even though later examina-

tion fails to reveal any structural changes in the brain, a post-epileptic hemiplegia of this kind persists for many days or weeks.

A persistent hemiplegia following an attack of migraine is still less common, but when it occurs this also is not due to any demonstrable lesion in the brain. Some elderly persons with or without changes of cerebral arteriosclerosis show recurrent hemiplegia, usually on the same side of the body, which clears up completely and is usually explained in terms of spasm of one of the larger cerebral arteries, although no satisfactory evidence supports this view.

Post-hemicranial

Recurrent hemiplegia

In the course of general paralysis loss of consciousness, followed by a transient hemiplegia which clears up completely, may be observed on several different occasions; these 'congestive' attacks of general paralysis are by some explained as due to recurrent oedema of the brain.

In general paralysis

The great majority of hemiplegias are due to structural changes in the cerebral cortex or along the course of the pyramidal tracts. In elderly persons thrombosis of the middle cerebral artery, which causes extensive infarction of the surface of the hemisphere and haemorrhage from the lenticulo-striate artery with consequent destruction of the internal capsule, are the commonest causes of hemiplegia. Thrombosis of smaller arteries of supply to one side of the mid- or hind-brain may be responsible for the different kinds of 'alternate' hemiplegia described in an earlier section (see p. 435). In younger adults exactly similar effects may result from embolic occlusion of these arteries or from the process of syphilitic endarteritis when it affects the intracranial vessels. Embolic hemiplegia is usually of instantaneous onset and is often transitory: this is so in carotid hemiplegia, in which an embolus obstructing the internal carotid artery on one side leads to blindness of the eye on the same side and a transient contralateral hemiplegia.

Vascular lesions

A cerebral tumour, whether neoplastic or granulomatous (tuberculoma), or a cerebral abscess, when it occurs in or beneath the motor cortex or when it occurs in a position which results in damage of one pyramidal tract at or below the internal capsule, can produce any of the kinds of hemiplegia mentioned above. Hemiplegic weakness which is strictly unilateral very rarely occurs in adults as a result of a non-suppurative encephalitis, but in infants and in children this is comparatively common.

Cerebral tumours

Encephalitis

Congenital hemiplegia is rare and is in most cases the result of haemorrhage into or over one side of the brain during delivery, but sometimes a simple developmental defect of one cerebral hemisphere or an attack of encephalitis during intra-uterine life appears to be the probable explanation.

Congenital hemiplegia

In early childhood hemiplegia may occur without any obvious infective cause and often without any evidence of disturbance of the general health. Some of these cases have been ascribed without any very satisfactory evidence to damage by the virus of acute poliomyelitis; for others a non-specific encephalitis of toxic or infective origin has been held responsible. Some of the common disorders of childhood are

Hemiplegia in childhood

associated with or followed by an encephalitis of which the chief residual symptom may be a persistent hemiplegia. Smallpox, chickenpox, vaccinia, and measles provide examples of this complication. The hemiplegia which has often been described in whooping-cough is often due to meningeal or to intracerebral haemorrhages presumably resulting from the paroxysms of coughing. The less common hemiplegia of diphtheria is usually due to arterial thrombosis or to embolism, and in later life cerebral thrombosis in the course of enteric and typhus fever may be responsible for a persistent hemiplegia. In comparatively rare cases cerebral syphilis resulting from the congenital infection has been associated with a hemiplegia due in most cases to arterial thrombosis.

8.—PROGNOSIS

The disease process originally responsible for hemiplegia must here be considered in its bearing on the probability of early recovery or of permanent weakness; and account must also be taken of whether or not this disease process is likely to be progressive or recurrent. Thrombosis, haemorrhage, or embolism of the cerebral arteries may give rise to a hemiplegia which is initially complete, but the outlook for recovery is on an average best in the embolic cases and worst in those due to cerebral haemorrhage. When extensive cerebro-vascular disease has led already to thromboses which have resulted in transitory hemiplegia on one or more occasions, the probability that further similar attacks will occur, that the hemiplegia resulting will be more severe and longer-lasting, and that it will prove fatal is very much greater; so that the ultimate prognosis in hemiplegia can only be regarded as at all favourable when it occurs in young persons in whom some intercurrent disease or morbid state has arisen, and in older persons in whom the hemiplegia is clearly attributable to syphilitic infection which can be actively treated.

Vascular lesions in relation to prognosis

Favourable and unfavourable signs

Apart from the above considerations the prognosis in a given case of hemiplegia in its earliest stages depends largely on the extent to which generalized cerebral activities are disturbed. In all cases in which coma is profound or long-lasting, recovery from the hemiplegia may be expected to be incomplete. If some degree of voluntary control is re-established in all parts of the hemiplegic side within a few days, the outlook with regard to functional recovery is very good. Conversely, if there is no recovery of power within a week, complete restoration of function cannot be expected; and, if considerable improvement is not evident at the end of a month, there can be very little reasonable hope that the patient will ever recover any useful degree of control. Prolonged flaccidity and the early establishment of contractures are both most unfavourable signs.

Rate of recovery

Except in hemiplegic patients who survive epileptic attacks in general paresis and disseminated sclerosis, complete recovery almost never

follows, particularly in respect of the hand and fingers when these have been affected. If the patient's general condition is satisfactory and his powers of co-operation are good, it can be anticipated that he will recover his ability to walk with the support of a stick after six weeks to three months, but it is particularly in these cases of moderate severity that the amount of functional recovery finally depends so largely on the ability to make the fullest use of the therapeutic measures outlined in the following section.

9.—TREATMENT

The treatment of the various causes of hemiplegia is dealt with under separate titles, e.g. APOPLEXY. Such treatment may be in some cases directed to limiting the extent of the structural damage responsible for the hemiplegia, but in many cases the gravity of the underlying diseases or pathological states renders the treatment of any resulting paralysis comparatively superfluous. Nevertheless in any case in which the chances of survival are considerable the practitioner should not become preoccupied with the vital issues to the extent of neglecting those earlier precautionary measures which may make later recovery from paralysis much easier. Clearly the treatment of hemiplegia itself is chiefly applicable to those cases in which the primary cause has been removed or has for the time being at least ceased to act. In some cases the amount of destruction of brain substance is so great that little can be done to remedy the complete paralysis thus caused, but in most cases the degree of recovery depends very largely on the management of the condition over the course of many months.

The extent to which recovery takes place in such circumstances depends on (i) the re-establishment of the patient's ability to initiate voluntary movements of varying complexity and (ii) the prevention or the removal of any mechanical impediment to such movements, e.g. contractures and spasticity. In all cases of severe hemiplegia the patient should be nursed upon a water-bed, and careful attention should be paid to the condition of the skin over all pressure points by further protective padding when this is necessary, by the avoidance of all rucks and creases in the underlying bed-clothes, and by treatment twice daily of the skin on the back, buttocks, heels, and elbows with methylated spirit and powder.

*Factors
determining
extent of
recovery*

Care of skin

The degree to which spasticity will develop depends almost entirely on the nature of the structural damage, and comparatively little can be done to check its appearance, although section of the posterior roots connected with the spastic limb has in some cases been carried out with advantage. Very soon after the earliest stages the limbs, sometimes at first flaccid, tend to assume positions which may afterwards become rigidly fixed as spasticity insidiously develops. Steps to prevent the adoption of such disabling postures should be taken from the beginning.

*Control of
spasticity*

The arm tends to become adducted at the shoulder and internally rotated, with full flexion at the elbow, fingers, and wrist. Adduction at the shoulder can be prevented by padding the axilla, and the arm should be kept in a position of extension of the elbow, supination of the forearm, and extension of the wrist and fingers; this may require the application of well padded splints. For similar reasons the leg should be kept in position with the ankle dorsi-flexed, the foot everted and rotated slightly outwards, and the thigh a little adducted. The above measures are applicable to a patient who is confined to bed. Directly he is up, checks to the development of faulty positions are less easy to apply, but he should not be allowed to carry his arm in a sling, and the wearing of an extension splint for the wrist and fingers may by its weight assist in keeping the elbow extended.

*Passive
movements*

Every joint of the paralysed limbs should be moved at least twice daily by passive manipulation throughout the full range of its ordinary movement, and, before active movements return, the patient should be encouraged to manipulate his paralysed limb in this way with the other hand. The risk of articular adhesions, particularly at the shoulder but also at the elbow, wrist, finger-joints, and knee, may in this way be minimized. When the arm splint is discarded, the fingers may be kept partially extended by placing some padded object or a rubber ball in the palm of the hand. Whenever this is practicable, repeated passive movements during the hours in which the patient is up may render the wearing of splints unnecessary at this time, but they should invariably be re-applied during the night.

Massage

Skilled massage should be given as early as possible and continued in suitable cases until the return of voluntary active movements is well established; it should always be painless and gentle. Contractured muscles should be coaxed into relaxation without being forcibly stretched, and any form of deep kneading should be restricted entirely to the muscles which are flaccid and whose contraction it is desired to increase. General stroking or effleurage of the paralysed limbs may be useful in assisting the circulation. The limbs should invariably be kept warm during these forms of treatment, in order that the spasticity may be diminished; for this purpose warm baths may be of great service. All forms of electrical stimulation should be rigidly avoided.

*Active
movements*

For the recovery of voluntary control the assiduous practice of such active movements as have returned and the frequently repeated attempts to revive hitherto absent movements are of primary importance. A very great deal depends on the skill and the sympathetic encouragement of the physiotherapist who carries out the treatment, in order that the patient's interest in his own improvement may be stimulated and that he shall not be allowed to become disheartened by delay, nor content to make shift with a mediocre performance. The order in which the recovery of movements normally takes place has been already described (see p. 429). Therefore, if at each stage efforts are concentrated upon corresponding movements, the most encouraging results will be

obtained, although at no stage should any movement be entirely neglected. The patient should be persuaded to put his movements to purposive use as early as possible. Walking should be encouraged directly he can stand with any security, and some implement should be placed in his hand directly movement at the elbow and wrist has reappeared.

Two procedures may be of great use in helping the recovery of voluntary control: if at a stage at which a given movement is not yet possible the patient is directed to concentrate upon an effort to bring about this movement and at the same time the movement is carried out by passive manipulation, recovery may occur earlier than if the limb in question is allowed to remain immobile; further, to use the sound limb for the production of precisely the same movement as is being simultaneously attempted by the hemiplegic limb often greatly facilitates the reappearance of active control. In those cases in which recovery becomes well advanced every effort should be made to increase the precision of movement until it is quite clear that nothing further can be gained. The patient should be encouraged to handle small objects with his fingers, to play games in which the precise use of his fingers is required, or to use his fingers, e.g. on a typewriter. He should practise walking in outlined footprints on the level and up and down short flights of stairs. No special apparatus will be required if skilled encouragement is available. All these lines of treatment are never superfluous even in the most severe case of hemiplegia. Without them milder cases may be allowed to remain at a level of most regrettable inefficiency, and, unless they are continued long enough, moderately severe cases may very greatly deteriorate.

*Value of
mental effort*

*Simultaneous
use of sound
limb*

*Progress in
precision*

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HEPATITIS

See AMOEBIASIS, Vol. I, p. 366; *and*
LIVER DISEASES

HEPATO-LENTICULAR DEGENERATION

SECTIONS 1, 4, 5, AND 6

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Reference may also be made to the following titles:

BRAIN: REGIONAL DIAGNOSIS LIVER DISEASES

1.—DEFINITION

(*Synonyms.*—Progressive lenticular degeneration; Wilson's disease;
pseudosclerosis)

666.] A fatal malady characterized by the progressive development in adolescents or young adults of wide-spread tremor and rigidity of the musculature, defects of articulation and deglutition, spasmodic weeping

and laughing, and a slight degree of dementia, and by the complete absence in uncomplicated cases of any true paralysis or of those alterations in the reflexes which are associated with lesions involving the pyramidal system. Pathologically the nervous lesion consists in bilaterally symmetrical degeneration of the lenticular and caudate nuclei, with degenerative changes in nerve-cells in the cerebral cortex. In addition, the liver constantly shows a profound degree of multilobular cirrhosis, which may be clinically latent.

2.—AETIOLOGY

Familial incidence

So far as is known the malady is not heritable, but numerous familial cases are recorded; thus Barnes and Hurst reported three cases in one generation, a fourth child dying of hepatic cirrhosis without the symptoms or lesions of lenticular degeneration (see p. 449). Beyond the fact that several members of a family are often affected and that occasional cases have been reported in other close relations nothing is known of the aetiology of the disease. It seems probable that the cerebral degeneration is secondary to the disease of the liver and somehow depends on it, but this relation is not clear.

Age and sex incidence

The disease most often begins between the ages of ten and thirty years, but the onset may be slightly earlier or later. The sex incidence is approximately equal.

3.—MORBID ANATOMY

The disease is characterized by the triad of multilobular cirrhosis of the liver, degeneration of the brain, affecting especially the corpus striatum, and deposition of pigment in the posterior elastic lamina (Descemet's membrane) in the cornea, the so-called Kayser-Fleischer zone. Of the three the alterations in the liver are the most striking and appear to precede the cerebral degeneration. It is very doubtful if cases in which the liver is found to be normal should be classed under the heading of hepato-lenticular or progressive lenticular degeneration. The corneal pigment, on the other hand, may appear late, and may be present only in certain sectors of the cornea of one eye, at a stage when the nervous symptoms are well established. It has, however, been found with remarkable constancy in cases examined with the slit-lamp.

(1)—Liver and Spleen

Liver

The liver is usually much shrunken and very firm. Its surface is rugose, with slightly raised nodules, which vary in size from a few millimetres to one or more centimetres in diameter. The capsule is not notably thickened. On section the liver substance has a mottled yellow or yellowish-brown colour, broken up by strands of grey fibrous tissue into

rounded or polygonal islands which vary greatly in diameter (see Fig. 64). Histologically the appearances vary with the stage of the disease. *Microscopical appearances*
In patients dying from an acute attack of hepatitis or during the stage of the earlier nervous symptoms there may be considerable degeneration of the parenchymal cells in the centres of the lobules, with infiltration of the portal tracts by inflammatory cells. The appearances in such cases



FIG. 64.—Liver in hepato-lenticular degeneration with wedge-shaped piece removed from posterior surface of right lobe to show cirrhotic appearance on section. Weight of liver was 935 grams. (From *Quarterly Journal of Medicine*, 1924)

are those of subacute hepatitis. In more chronic cases there is little evidence of parenchymal degeneration beyond some fatty infiltration in the periphery of the lobule, and the fibrous septa may not show any sign of inflammation. In many cases a greenish-brown pigment has been found in some of the liver-cells, but there is not any iron pigment nor any swelling of Kupffer cells.

Spleen

The spleen is slightly enlarged and fibrotic, but the changes here are mild by comparison with the cirrhosis of the liver, to which they are secondary.

(2)—Brain

Brain
Naked-eye
appearances

The brain does not present any external abnormality, although it may be slightly shrunken, especially in the region of the insula (island of



Fig. 65.—Brain in hepatolenticular degeneration. Horizontal section of left hemisphere at plane of Marie's *coupe d'élection*. Putamen and caudate nucleus are much shrunken and darker than normal. Compare Fig. 66. (From *Quarterly Journal of Medicine*, 1924)

Micro-
scopical
appearances

Reil). On section through the basal ganglia there is not seen, in most cases, any gross softening of these structures, although the cavitation in the putamen which was apparent in some of Wilson's original cases may be present in various degrees. In all cases, however, there is a considerable degree of shrinkage of both the putamen and the caudate nucleus, which is greatest in the posterior two-thirds of the putamen. In horizontal sections the normal smooth convexity of the outer border of the lenticular nucleus is superseded by a sinuous curve with a concavity just behind the centre of the nucleus (see Figs. 65 and 66). In coronal sections the local shrinkage of the putamen is not so easily made out. There is often a tendency for a split to form along the outer border of the putamen, separating it from the external capsule and claustrum. The colour of the putamen and often also of the caudate nucleus and nucleus subthalamicus (corpus Luysii) is darker than normal and sometimes has a brick-red tinge. Small softenings of the inner layers of the cortex or small areas of irregular coloration in the cortex may be seen.

Microscopically the most striking abnormality in the putamen is its great cellularity. Most of the cells have the oval vesicular nucleus and narrow zone of cytoplasm of neuroglial astrocytes; but the small darkly

staining nuclei of oligodendroglial and microglial cells are also plentiful. The small nerve-cells are not easily distinguished from the neuroglial astrocytes, for their cell body is shrunken and devoid of Nissl's granules and the outline of the cell is irregular; often the nuclear membrane is folded, or the nucleus may stain more darkly than normal. Similar or more severe degenerative changes are seen in the larger nerve-cells, which often are surrounded by satellite cells or may even be undergoing

neuronophagy. It is difficult, owing to the general shrinkage of the nucleus and to its richness in neuroglial and other cells, to estimate if, or to what degree, there has been actual loss of nerve-cells, but certainly in most cases the larger nerve-cells are less numerous than normal.

The type of giant neuroglial cell first described by Alzheimer in a case of pseudosclerosis may usually be found, although rarely in such large numbers as in his case. Such cells show by ordinary staining methods

Neuroglial cells

usually one but occasionally two or three large pale nuclei, oval or reniform in shape and from three to six times the diameter of that of a normal astrocyte. Often the nuclear membrane is irregularly folded, and only two or three small granules of chromatin are seen within it, but hyperchromic nuclei may also occur. Occasionally in sections stained with toluidine or thionin blue an irregular zone of greenish granules can be seen round the nucleus, but the cytoplasm is not stained except by special methods. Alzheimer's fuchsine-light-green method shows that it is irregularly rounded and has short blunt processes but not any fibres. These cells are most often seen in the putamen but may also be present in the caudate nucleus and cerebral cortex. They have also been found in the hypothalamus, pons, and dentate nucleus. Although first found in pseudosclerosis and for a time considered as limited to that form of disease, they have been seen, although perhaps in smaller numbers, in typical cases of Wilson's disease. They are practically specific for hepatolenticular degeneration, although similar cells, of smaller size, have been found in the cerebral cortex in general paralysis.

In spite of the large numbers of neuroglial cells present in the putamen, there is rarely any formation of neuroglial fibres, such as is seen, for example, in Huntington's chorea (see Vol. III, p. 211). In old-standing cases, especially those in which some rarefaction or vacuolation has taken place in the nucleus, neuroglial fibres may be present round some of the vessels, but they are never abundant.

With stains for fats a variable number of fat-granule cells may be seen in the putamen. They occur most often in clumps near the centre or in the posterior half of the nucleus. Sometimes they are limited to the walls of the vessels both in the lenticular nucleus and in the cortex. Granules or concretions of material which gives the staining reactions of iron may also be seen along the walls of the vessels in the lenticular

Fat-granule cells



FIG. 66.—Normal brain. Horizontal section of left hemisphere, showing normal volume of components of corpus striatum. (From *Quarterly Journal of Medicine*, 1924)

nucleus as well as in the cortex. Apart from these infiltrations the vessels are usually normal, although they may be more numerous than normal. Hyaline changes in the vessel walls have occasionally been described.

Cerebral cortex

The cerebral cortex has been reported as affected in most cases which have been examined since Wilson's paper appeared. Most commonly there is a fairly wide-spread change of a similar type to that seen in the putamen but of much less intensity, i.e. excess of astrocytes with degenerative changes in the pyramidal cells but without overgrowth of neuroglial fibres. There is often some excess of small vessels, sometimes most marked in localized areas, which are visible to the naked eye. Actual softening of the inner layers of the cortex over a few gyri is rarely present. In most cases the changes are diffuse and so slight that they are recognized only on careful examination.

Brain-stem

Degeneration of the main fibre-systems passing from the lenticular nucleus to the thalamus and mid-brain is seen in old-standing cases, and there may be slight degenerative changes in the cells of the dentate nucleus as well as the presence here and in the pons of Alzheimer's type of neuroglial cell. Otherwise the brain-stem is usually intact. 'Calcification' in the region of the vestibular nuclei has also been described. No lesions have been described in the spinal cord.

(3)—Corneal Pigment (Kayser-Fleischer Zone)

Site of deposition

The changes in the cornea are limited to the deposition of pigment in the outer zone of the posterior elastic lamina (Descemet's membrane), the corneal fibres and the internal epithelium remaining normal. The pigment appears near the outer limbus of the membrane as a layer of very fine granules of dark brown colour which become sparser as the membrane is traced inwards and usually disappear completely half-way towards the centre of the cornea.

Nature of pigment

The nature of this pigment is not known with certainty, for the micro-chemical examinations made of it in different cases have given discordant results which cannot be explained only on differences in fixation, e.g. by alcohol or formalin. All observers agree that it is not melanin, nor does it give the reactions of any of the known pigments derived from haemoglobin. Hall considered that it was probably silver, and this opinion is shared by some later workers (Lüthy). Others (Kubik; Rohrschneider) found no silver in the cornea. Kubik considered that it was a degenerative pigment similar to that found in the nerve-cells of the sympathetic ganglia, and Rohrschneider found some similarity between the corneal pigment and malarial pigment but did not exclude the possibility that it contained copper. The latter derivation is supported by the occasional presence in cases of hepato-lenticular degeneration of a 'sunflower' cataract similar to that which occurs when fragments of copper penetrate into the anterior chamber of the eye.

Abnormal storage of copper

Both the lens and the brain, in cases of hepato-lenticular degeneration, have been shown to contain an excess of copper over the normal, and

up to fifty times the normal quantity of copper has been found in the liver. This probably indicates an abnormal storage of copper by the tissues in hepato-lenticular degeneration and does not prove that the disease is in any way due to poisoning by copper.

4.—CLINICAL PICTURE

In the recognition of a new disease it is inevitable that only those cases which correspond to a single clear-cut picture can be identified, but with growth of experience it has been found here, as elsewhere, that the clinical picture and the pathological lesion vary within wide limits.

Thus the tremor which was so striking a feature of Wilson's original cases has not always been found in later verified cases of the disease. It is occasionally absent or very late in development, and cases have been recorded in which the involuntary movements have been of a writhing character (torsion spasm). *Tremor*

The clinical picture contains the usual features of disease involving the extrapyramidal motor system, i.e. rigidity, involuntary movement, absence of true paralysis, and absence of qualitative change in the reflexes. Sensation is not impaired, and sphincter control is retained until the terminal stage of the illness. *Signs of extra-pyramidal lesion*

Tremor may be the initial symptom. It is of the Parkinsonian type. Diffuse muscular rigidity gradually develops and with it a progressive disorder of articulation leading finally to anarthria. Dysphagia also develops and may in part be responsible for the emaciation which is present in the later stages of the illness. The patient tends to adopt a general attitude of flexion, in which the muscular rigidity fixes him, rendering him finally bedridden and helpless. *Rigidity Anarthria Dysphagia*

A common sign, but in some cases elicited only by slit-lamp examination, is the presence of the Kayser-Fleischer ring of pigmentation at the limbus of the cornea. This is seen as a zone, about two millimetres wide, of greenish-brown haze at the periphery of the cornea. When illuminated obliquely it may cast a faint but appreciable shadow on the iris. Its nature has already been discussed (see p. 448). *Kayser-Fleischer ring*

In the series of four cases in one family described by Barnes and Hurst all four children presented clinical indications of an hepatic lesion, accesses of fever, attacks of slight jaundice, ascites, and haematemesis; three of them also developed the signs of a nervous lesion, whereas in one these signs were absent. In the first three the characteristic nervous lesions of hepato-lenticular degeneration were found at the necropsy, but not in the fourth. This last-mentioned case presented convulsions as a terminal symptom, and in all four the mode of death suggested a severe toxæmia. In most of the recorded cases there has not been any clinical indication of an hepatic lesion.

The incidence of psychical disturbance is uncertain. In the cases of Barnes and Hurst symptoms of this order, though never severe, were *Mental disturbance*

noted at an early stage in the clinical course of the malady, and their presence may be correlated with the cortical lesions described by these observers.

In short, hepato-lenticular degeneration is not the pure extrapyramidal system disease it was originally believed to be, and in a few cases the cortical lesions may be more striking than those in the lenticular nuclei.

Final stage In the final stage of the illness the patient lies immobile in bed, extremely rigid, and with a fixed spastic smile (see Fig. 67). There is

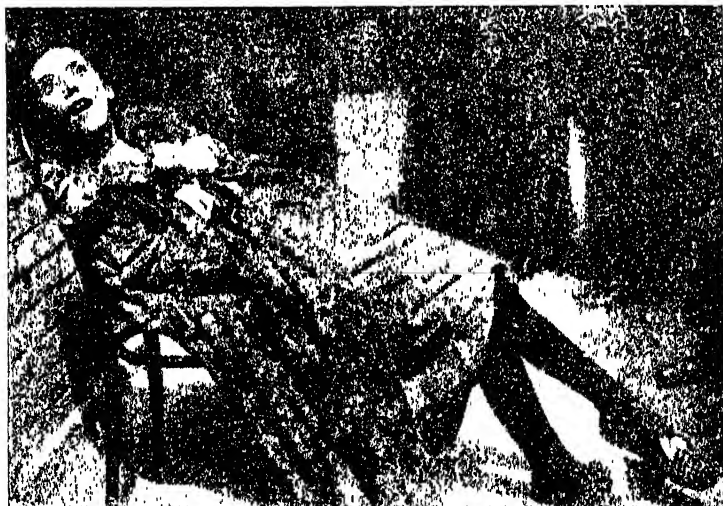


FIG. 67.—Hepato-lenticular degeneration. Aspect of patient three months before death. (From *Quarterly Journal of Medicine*, 1924)

complete anarthria, and deglutition is gravely disordered. Tremor or coarse irregular involuntary movements may be present. The tendon-reflexes are brisk until intense muscular rigidity renders their elicitation impossible. The plantar responses remain of the flexor type. There may be considerable dementia, and the terminal incontinence of urine and faeces may be related to this state. The pupil reactions remain normal, and the ocular movements, though sometimes slow and restricted in range, are not otherwise disturbed.

There is profound emaciation in this terminal period of the illness, and bed-sores may develop.

5.—DIAGNOSIS

There are points of resemblance to post-encephalitic Parkinsonism, but in hepato-lenticular degeneration the grave disorder of articulation and of deglutition, the indications of an hepatic lesion, the presence of the

ring of corneal pigmentation, and the dementia should make differential diagnosis possible, even though not all these distinguishing signs may be present in every case of the disease.

6.—COURSE, PROGNOSIS, AND TREATMENT

It has already been stated that the disease is progressive and uniformly fatal, and no treatment is known to influence its course.

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HEREDITY AND CONSTITUTION

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Reference may also be made to the following titles:

BLOOD TRANSFUSION	MENTAL DISEASE,
EYE, HEREDITARY	HEREDITY
DISEASES	PATERNITY, DISPUTED

1.—MENDELIAN INHERITANCE

*Mendel's
experiments*

667.] The experiments of Mendel on plants showed that characters were transmitted independently of one another and that, though some might be rendered latent for generations, none were ever lost. He chose simple pairs of contrasted characters for each series of experiments. In one, for example, he dealt with the inheritance of tallness and dwarfness in peas. Having previously found that each bred true he crossed them and obtained all tall plants. These tall plants were crossed *inter se* and gave rise to both tall and dwarf plants in the proportion of three tall to one dwarf. When the tall plants thus obtained were self-fertilized the results were either all tall plants or tall and dwarf plants in the proportion of three to one, the latter result occurring twice as often as the former. Seeds from a cross between two dwarf plants always produced dwarfs. In no case were there any intermediates.

The character of tallness renders that of dwarfness latent and is therefore said to be dominant, while that of dwarfness is said to be recessive.

*The terms
'dominant'
and
'recessive'*

Mendel's experiments, unnoticed for many years, were confirmed and made widely known by Bateson, and animals, both vertebrate and invertebrate, were found to transmit various characters in exactly the same way.

Independent work by cytologists on the behaviour of the germ-cells during oogenesis and spermatogenesis showed that the chromosomes were arranged in pairs; furthermore it was established that the number

*Maturation
of the germ-
cells*

of chromosomes in the germ-cells was reduced to half that in the somatic cells, one chromosome of each pair being present in each

*Reduction-
division*

gamete, and that in the zygote formed by the union of a spermatozoon with an ovum the full (paired) somatic number was regained, one member of each pair being derived from each parent. It was also discovered that, with some rare exceptions, the number of chromosomes was constant in each species, though there were very wide variations in the number in different species. These facts explained the phenomena observed by Mendel and his successors. More recent work on the fly *Drosophila* has proved that in each chromosome there is a constant linear arrangement of the chromatin granules, and that the various characters are governed not merely by a particular chromosome but by a particular part of that chromosome. The units on the chromosome, each of which governs an individual character, are known as genes.

*Chromosome
subdivisions*

Corresponding or homologous chromosomes (i.e. members of a pair) are called autosomes and the genes which they carry are known as autosomal genes. They may both carry the same gene, or one of them may carry a gene alternative to that carried by the other and having a different effect on the character thus controlled. Such a pair of alternative genes are known as allelomorphs. There may even be several such genes forming a series of multiple allelomorphs, any one of which may be substituted for any other; but only one can be present in any germ-cell and only two in any zygote. These allelomorphs stand in a definite order of dominance; for instance if there are three, A, B, and C, B may be recessive to A, but dominant to C, in which case C will be recessive to both A and B.

*Mendelian
allelomorphs*

If an individual receives a similar gene from each parent, he is said to be homozygous for the character it governs, but if he receives one gene from one parent and its allelomorph from the other parent, he is said to be heterozygous for the character. In the former event all his germ-cells, when the reduction-division takes place, will carry the same gene, but in the latter case half will carry one gene and the other half its allelomorph. A cross between an individual homozygous for a dominant gene (DD) and one homozygous for its recessive allelomorph (RR), produces offspring all possessing the dominant character and resembling the parent; for, though all are heterozygous (DR) and carry both the dominant and the recessive genes, the latter does not

*Homozygous
and
heterozygous
characters*

*Results of
various
crosses*

produce any visible effect (see Fig. 68). The germ-cells from this hybrid will be of two kinds in equal numbers, half carrying the dominant gene D, and half carrying the recessive R, so that, if paired *inter se*, the progeny will be constituted DD: DR: RD: RR in equal numbers; three-fourths will show the dominant character like the parents, one being homozygous and two heterozygous for it, but the remaining fourth will be a homozygous recessive, unlike either parent. A cross between two homozygous dominants (DD × DD) will give nothing but pure dominants (DD); a cross between a homozygous dominant and a heterozygote (DD × DR) will give progeny all with the dominant character, but half of them will be heterozygous (DR); a cross between a heterozygous dominant and a recessive (DR × RR) will give half heterozygous dominants (DR) and half recessives (RR); but two homozygous recessives crossed (RR × RR) will give nothing but recessives (RR). These various possibilities are illustrated diagrammatically in the following tabulations.

Examples of possible crosses

(a) Marriage between a homozygous dominant (DD) and a homozygous autosomal recessive (RR):

Zygotes	—	DD			RR
Gametes	—	D	D	R	R
Zygotes	—	DR		DR	DR

All heterozygous dominants

All the children will manifest the dominant character.

(b) Marriage between two heterozygous dominants (DR):

Zygotes	—	DR		DR	
Gametes	—	D	R	D	R
Zygotes	—	DD	DR	DR	RR
		Homozygous dominant		Heterozygous dominants	Homozygous recessive

Three children will manifest the dominant character and one the recessive character.

(c) Marriage between a heterozygous dominant and a homozygous recessive:

Zygotes	—	DR		RR
Gametes	—	D	R	R
Zygotes	—	DR	DR	RR
		Heterozygous dominants		Homozygous recessives

Half the children will manifest the dominant character and half the recessive character.

Such is the mechanical basis for the segregation of Mendelian characters. It may be pointed out that, though dominance is usually so complete that homozygotes cannot be distinguished from heterozygotes, there

are in some cases differences which make it possible to distinguish one from the other; in other cases the genes are equally potent and the heterozygote is intermediate in character.

2.—DOMINANT, RECESSIVE, AND SEX-LINKED INHERITANCE IN MAN

668.] In the case of the rarer dominant abnormalities in man the usual marriage is that between an individual heterozygous for the abnormality and one homozygous for the normal condition ($DR \times RR$), and the

Dominant abnormalities in man

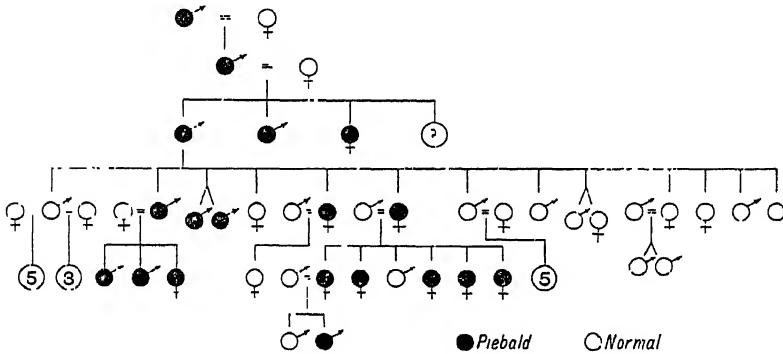


FIG. 68.—Pedigree showing inheritance of autosomal dominant piebaldness. (*Biometrika*, 1914)

condition is transmitted by those affected to half their children (see p. 454, c). Brachydactyly, multiple exostoses, the facio-scapulo-humeral

Examples

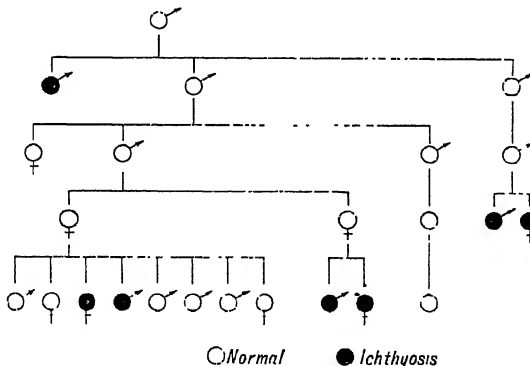


FIG. 69.—Pedigree showing inheritance of autosomal dominant character with dominance incomplete: ichthyosis simplex. (*Norsk Magazin for Laegevidenskaben*, 1920)

type of muscular dystrophy, acholuric jaundice, congenital cataract, piebaldness, ichthyosis simplex, and many other defects are inherited in this way (see Figs. 68 and 69). Most of the dominant defects of

nian have never been seen in the homozygous form; and the common statement that dominant are less severe than recessive defects may be incorrect, for in the homozygous state they might be far more severe or even lethal, as is the case with many of those occurring in *Drosophila* and in fowls.

*Recessive
defects in
man*

In man recessive inheritance of rare defects may be suspected when the defect appears either in a child or children whose parents both seem normal, or in separate fraternities of a family, for example in cousins. Both parents in such cases are heterozygous for the defect, but the corresponding dominant gene for normality renders that for the defect latent (see Fig. 70). Albinism, alkaptonuria, porphyria, the infantile

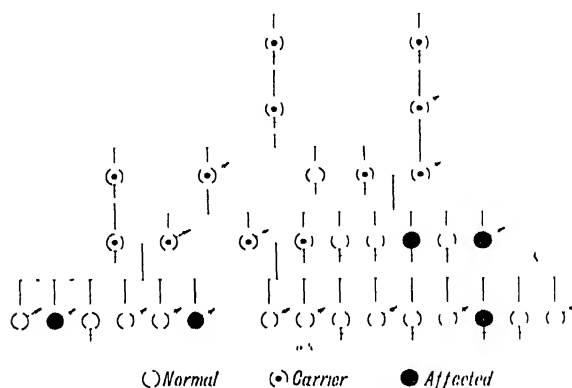


FIG. 70.—Pedigree showing inheritance of autosomal recessive character: epileptic myoclonus (after Lundborg). Three consanguineous marriages, resulting in children with the abnormality

and juvenile forms of amaurotic idiocy, deaf-mutism, complete colour-blindness, epileptic myoclonus, and ichthyosis congenita are among the recessive defects of man.

*Effects of
con-
sanguineous
marriages*

Heterozygotes for defects, though much more numerous than homozygotes, are very few amongst the general population, but in a family in which the defect has recently appeared, and sometimes in one in which it has not appeared for generations, there are a considerable number of heterozygotes. Hence intermarriages between two members of such families are much more likely to be marriages between two heterozygotes and to result in abnormal children than are marriages between members of these families and unrelated people.

Thus the best proof that a rare human abnormality is recessive is the high rate of consanguinity in the parents of children with the abnormality, and marriages between first cousins are the most valuable as a criterion, because more is known about their frequency. The rate varies in different localities, being lowest in big towns and highest in isolated communities. It is also high among Jews and Quakers. The average throughout England is between a half and one per cent, and in London it is less than one per cent. Many recessives are rare in London,

although there may be several examples of one or other of them in each of a small group of remote villages, as Hanhart has shown to be the case with Friedreich's ataxy in some of the mountain villages of Switzerland and as Sjögren has found in an isolated district in North Sweden, where he discovered forty families, all either closely or distantly related, containing 67 imbeciles of the same type in a population of 7,000. The average number of mentally deficient individuals of all types in such a population is 28 and of imbeciles 3.

If the percentage of first-cousin marriages giving rise to some abnormality is much above one, it is probably recessive, and the rarer the abnormality the higher will this percentage be. In the case of deaf-mutism with retinitis pigmentosa, 17 per cent of the parents are first cousins; in albinism 22 per cent; in infantile amaurotic idiocy in Jews 12 to 16 per cent, but in gentiles and Japanese, among whom it is rarer, 35 and 46 per cent respectively; in xeroderma pigmentosa 47 per cent; and in ichthyosis congenita 49 per cent.

Illustrative examples

It must not be thought that consanguineous marriages are necessarily harmful; they only bring to light recessives latent in the stock, and, if the stock is sound, are no more disadvantageous than random marriages.

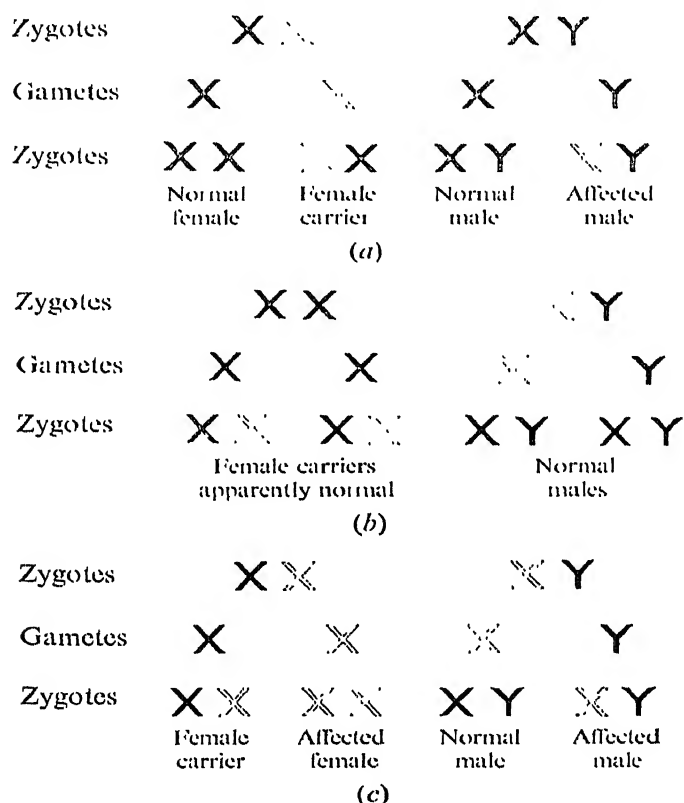
If a person with a recessive abnormality marries one heterozygous for it, half the children should have the abnormality and half should be normal; and the figures for albinism agree very closely with those expected. If two persons with the same recessive abnormality marry, all the children will be abnormal. Five such marriages between albinos have been recorded and all the children were albinos.

Many marriages between deaf-mutes have been recorded, and in some cases all the children were deaf-mutes, but in others they were normal. One reason for this is that, although both are recessive, deaf-mutism with retinitis pigmentosa is genetically different from simple deaf-mutism, and another is that the condition in one or both parents was acquired.

The autosomal chromosomes or autosomes are the ordinary chromosomes, of which there are twenty-three pairs in man, as opposed to the sex-chromosomes, X and Y. The autosomal chromosomes are alike in both sexes and form homologous pairs, but this is not the case with the sex chromosomes. In the human male these are dissimilar and are known as X and Y, the latter carrying no genes, or none allelomorphic with those in the X-chromosome; but they are alike in the female, who has two X-chromosomes. This accounts for the peculiar inheritance of sex-linked characters which are carried on the X-chromosome and which, being recessive, are manifest in the male but masked in the female by the dominant allelomorph in the other X-chromosome. The usual marriage resulting in children with a sex-linked recessive character is that between a heterozygous female (a carrier) and a normal male (see Fig. 71, *a*); half the sons and half the daughters are normal and incapable of transmitting the character to any of their descendants, half

Sex-linked inheritance

the sons manifest the character, and half the daughters are carriers. Marriages between a male with the character and a normal female are not uncommon, and all the sons are normal, but all the daughters are carriers (see Fig. 71, *b*). A sex-linked character can appear in a female



X = X-chromosome carrying dominant gene for the normal condition.
 $X \times$ = X-chromosome carrying recessive gene for the abnormal condition.
 Y = Y-chromosome carrying neither gene.

FIG. 71.—Diagram showing inheritance of sex-linked recessive character. (*a*) Marriage between female carrier and normal male; (*b*) marriage between normal female and affected male; (*c*) marriage between female carrier and affected male

if the requisite marriage takes place, namely, one between a male with the character and a female carrier, and half the daughters and half the sons have the character, the other half of the daughters are carriers, and half the sons are normal (see Fig. 71, *c*).

In the case of abnormalities in man such marriages are usually con-

sanguineous, and have occurred with the expected result in the case of megalocornea and sex-linked ichthyosis. Red-green blindness is much the commonest sex-linked defect and many illustrative pedigrees have been recorded (see Fig. 72). Females with red-green blindness have married normal males and, as expected, all their sons have had the defect and all the daughters have been carriers. When both parents have a sex-linked recessive abnormality all the children inherit it, and this has actually happened in the case of red-green blindness. Haemophilia, pseudo-hypertrophic muscular dystrophy, and the anidrotic ectodermal dysplasia in which the sweat glands are absent, the hair is scanty, and

Examples of sex-linked inheritance

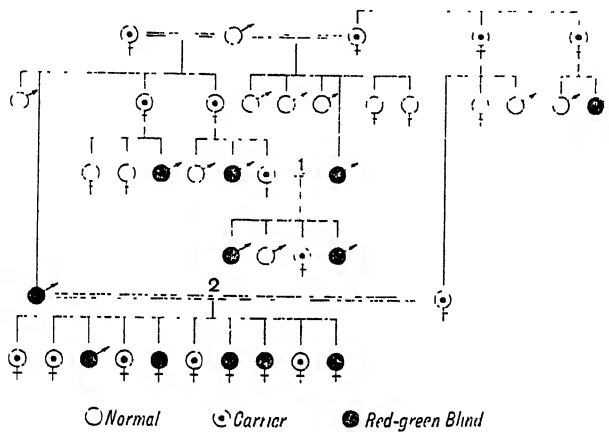


FIG. 72.—Pedigree showing sex-linked inheritance of red-green blindness. Two consanguineous marriages, 1 and 2, between an affected male and a carrier. From the first there are two affected males deriving the sex-linked recessive gene from their mother, and from the second there are four affected females deriving the gene from both parents. (After *Eugenics Laboratory Memoirs*)

the teeth absent or conical, and in some families ichthyosis simplex, microphthalmos, nystagmus, and retinitis pigmentosa, are inherited as sex-linked recessives.

Haldane (1936) has pointed out that the genes for some abnormalities, which are usually classed as autosomal recessives, show a peculiar type of inheritance. There is a strong tendency in the sibships either for all the males to be abnormal and the females normal or vice versa. He considers that the X-chromosome consists of two parts, one which determines sex and carries the genes determining the recognized sex-linked characters such as haemophilia, and another which carries the genes under consideration and which frequently crosses over with a corresponding part of the Y-chromosome. In this group of genes, if the gene for the abnormality is in the father's Y-chromosome the affected children will be males, and if in the father's X-chromosome they will be females (who will either manifest or carry the character), unless crossing-over takes place. As examples of these partially

Partially sex-linked conditions

sex-linked conditions he gives achromatopsia (complete colour-blindness), xeroderma pigmentosa, Oguchi's disease, epidermolysis bullosa dystrophica, and retinitis pigmentosa without deafness.

*Multiple
genes*

Some characters of animals are governed by a number of genes, situated in different chromosomes, each of which acts on a character in a similar way and therefore intensifies it, and there is evidence that many characters in man, such as pigmentation of the skin, are of this nature. These genes, which are not allelomorphic, are known as multiple genes.

*Double
dominants*

Other characters need the co-operation of two independent genes neither of which, in the absence of the other, produces any recognizable effect, and both genes may be dominant, both recessive, or one may be dominant and the other recessive. Inheritance of this kind is difficult to prove, but a careful analysis of the data available makes it probable that several abnormalities in man are double dominants. Cystinuria and, in Japanese families, Leber's optic atrophy may be examples (see Vol. V, p. 233).

*Conditional
dominants*

According to Levit most of the genes determining abnormalities in men are dominant, but often, to use his term, are 'conditional dominants' only, failing in the heterozygous state to manifest themselves. This would explain the occurrence of conditions which in some families are transmitted regularly by direct descent, in others skip generations, and in others appear sporadically.

*Incomplete
recessives*

Levit has also suggested that autosomal and sex-linked recessive abnormalities are seldom completely recessive, so that occasionally males and females who are heterozygous for an autosomal character, and females who are heterozygous for a sex-linked character, show the pathological condition. In his view most pathological genes in man were originally dominant, but, by the evolution of modifying genes, are gradually becoming recessive. Those which often fail to manifest themselves in the heterozygous state or only do so late in life show a stage in this evolutionary process from dominance to recessiveness.

*Interaction
of hereditary
and
environmental
factors*

Experimental breeding in animals has given many anomalous results. In some instances it has been proved that the character is determined by a dominant or a recessive gene, but requires some special environmental factor to make it apparent. In *Drosophila*, for example, reduplication of the legs is determined by a dominant gene, but appears only when the larvae are kept at a temperature of 10° C. It is probable that similar cases occur in man, the incidence of congenital pyloric stenosis and mongolism, for instance, indicating that they are caused by a genetic factor acting in conjunction with an environmental one. In these two conditions the extrinsic factor operates during embryonic life, but in many others it acts at some period after birth. An important aetiological factor in mongolism is the age of the mother (Penrose). Allergy with its varied manifestations, e.g. hay-fever, asthma, Besnier's prurigo, urticaria, and migraine, is determined by a dominant gene; but the external factors, such as pollens, dandruff from fur, feathers, orris root, and foods, operate during childhood or adult life.

3.—INHERITANCE OF DISEASES

669.] High arterial blood-pressure with its sequelae, arteriosclerosis, *Hyperpiesia* cerebral haemorrhage, hypertrophy of the heart with cardiac failure, and arteriosclerotic kidneys leading to uraemia, occurs in some families with far greater frequency than among the general population. The Medico-Actuarial Mortality Investigation in New York showed that the death-rate was excessive among insured persons in whose near relations two or more deaths had occurred from apoplexy; deaths in this group were 26 per cent higher than the number anticipated and deaths from apoplexy were particularly high—namely, twice as great as the anticipated figure.

Though accurate pedigrees are difficult to obtain in the case of diseases causing death in middle age or later, some very remarkable examples have been published. Badia, for instance, published one of abnormally high blood-pressure in three successive generations, ten members of the family being affected and only four normal. Weitz has also published the pedigree of a family in which both parents and four of their seven children had abnormally high blood-pressure.

It appears not only that the liability to arterial degeneration is inherited but that there is a tendency for the brunt of the disease to fall on a particular part of the arterial system, so that in one family death takes place from cerebral haemorrhage, in another from coronary thrombosis, and in yet another from uraemia.

There is still some doubt how far external causes are responsible for arterial hypertension, and on this question the study of uniovular twins should throw some light. In one case both members of a pair developed high blood-pressure at the age of sixty-four, though one had to work hard for his living and the other lived a life of ease. This supports the belief of Weitz that personal habits are aetiologically less important than the constitutional predisposition, but more observations are needed to prove this. Arterial hypertension is determined by a dominant gene. *Influence of environment*

Peptic ulcer often attacks several members of a fraternity and there may be a history that one of the parents suffered from it. It is five times as common among the parents, brothers, and sisters of persons with peptic ulcer as among the parents and siblings of persons free from this disease. *Peptic ulcer*

Although the ulcer cannot be inherited, hyperchlorhydria, which predisposes to it, is determined by a dominant gene, and irregular and unsuitable meals play a part in its production. Pernicious anaemia is often secondary to achylia gastrica (see Vol. I, p. 126), in which there is absence or deficiency of the secretion of the pyloric glands and of Brunner's glands in the duodenum, as well as of the fundal glands. Achylia gastrica is inherited as a dominant in some families and remarkable pedigrees have been published of families in which several members *Hyper-chlorhydria*
Achylia gastrica

in successive generations suffered from pernicious anaemia or subacute combined degeneration of the cord.

Diabetes mellitus

The normal variation in the activity of the endocrine glands is probably determined genetically and there is no doubt that in some cases their abnormal activity is so determined. Constitutional weakness of the islands of Langerhans is undoubtedly inherited and appears to be recessive, but it is doubtful whether the weakness which results in diabetes mellitus in children and young adults is genetically identical with that which predisposes to that disease in the middle-aged and old. Many relatives of diabetics are found to have a high blood-sugar after the ingestion of glucose, and are potential diabetics though they may never develop the disease. The fall in the incidence of diabetes mellitus throughout Europe during the lean years of the war showed clearly that diet is an extrinsic factor of great importance in its aetiology.

Toxic goitre

Toxic goitre, or a predisposition to it, is inherited as a dominant in some families, but an additional factor, such as sepsis, or in women pregnancy, may be necessary to produce the disease. The great frequency of the condition in certain families in those parts of Australia and America in which endemic goitre is common shows that, in addition to an inherited weakness, an external factor which damages the thyroid gland is necessary to produce thyrotoxicosis.

Diabetes insipidus

Diabetes insipidus is usually caused by local disease or trauma of the pituitary and hypothalamic regions, but in some families it is inherited as a dominant and no external factor has any influence.

Mental diseases

Manic-depressive insanity

The inheritance of mental diseases is complex (see MENTAL DISEASE, HEREDITY), but that of Huntington's chorea, an exception, is determined by a single dominant gene (see Vol. III, p. 212). Manic-depressive insanity shows a type of inheritance resembling that of a dominant character in some respects and that of a recessive in others, and is probably determined by one dominant and two recessive genes. In families in which the psychosis has appeared, there are some members who are unduly moody and sensitive, though they never develop manic-depressive insanity. These mentally abnormal people are probably heterozygous for one of the recessive genes.

Dementia praecox

Schizophrenia or dementia praecox is unusually prevalent in the Parsi community of Bombay, in which consanguineous marriages are very common, and in Europe the percentage of first-cousin marriages giving rise to it is double that amongst the general population, a significant excess in so common a disorder. This shows that a recessive gene must be concerned, but a single recessive gene will not explain its incidence. In some families in which there are members with schizophrenia, there are others who are unsociable, cold, self-centred, and without a sense of humour, the so-called schizoid psychopaths, and it has been suggested that they are heterozygous for one of the genes, while the true schizophrenics are homozygous. The number of pairs of uniovular twins with the same type of schizophrenia shows not only that the psychosis is inherited, but that the form it takes is also predetermined. Exceptional

cases occur, however, in which only one member of a pair has schizophrenia. Possible explanations of this are given in the section on Twins (see p. 466).

It has been proved that immunity to certain bacterial diseases of animals, such as bacillary white diarrhoea of chickens and hog cholera, is determined genetically; and, by breeding from the survivors of epidemics, strains with greatly increased resistance have been isolated. Irwin, for example, injected rats with a known quantity of Danysz's bacilli and reduced the mortality in a few generations from 82 to 17 per cent. Immunity to most of these diseases appears to be determined by several genes, at least one of which is dominant, and immunity in man is probably equally complex. *Inheritance of immunity*

In man diseases conferring relatively short periods of immunity, such as influenza, tonsillitis, and pneumonia, attack the members of some families with undue frequency, this inability to resist invasion appearing to be in part inherited. Pearl gave a most impressive instance of familial susceptibility to pneumonia. In a fraternity of thirteen all had pneumonia before the age of eighteen years, one of them had it twice, one three times, and seven died of it.

In the case of chronic diseases, such as tuberculosis, the organism gains entrance into the bodies of the great majority of the population, but only a small percentage develop clinical tuberculosis. With a disease of such long duration it is very difficult to assess the relative importance of heredity and of the various environmental factors which undoubtedly play a part in its aetiology. Carefully collected and analysed data, however, show that an inherited susceptibility exists in some families. Those published by von Verschuer and by Diehl on tuberculosis in a hundred pairs of twins are most valuable. It was found that in uniovular twins both members of a pair developed the disease far more often than in binovular twins, and this was true even when the environment of the pair had been different. *Tuberculosis*

There is no doubt that a predisposition to rheumatism is also inherited, for its incidence in the close relatives of rheumatic children is 12·4 per cent, but in those of controls it is only 5 per cent. *Rheumatism*

A remarkable pedigree showing inherited susceptibility to infection was published by Grüneberg. It concerned a Jewish family living in West Germany. Sixteen members in three generations suffered from a chronic relapsing inflammation of the nasal, frontal, maxillary, and ethmoidal sinuses, and in one or more of the sinuses most of the patients developed an empyema. No mention is made of the organism, nor is it stated whether the same organism was responsible in all the cases. One male and one female transmitted the condition without suffering from it, and presumably they had the diathesis but were fortunate enough to escape the disease. With these two exceptions it was transmitted by direct descent, and behaved as if determined by a single dominant gene. *Sinusitis*

Most of the normal characters in man are determined by several independent genes, but the inheritance of the blood groups, physiological *Inheritance of blood groups*

characters which are becoming more important with the increasing use of blood transfusion, is comparatively simple. There are two agglutinogens, A and B, in the red corpuscles, and two corresponding agglutinins, α and β , in the sera. When A is present in the corpuscles β is the agglutinin in the serum and vice versa, but in some cases neither A nor B is present and there are both agglutinins in the serum, and in others both A and B are present in the corpuscles and neither α nor β in the serum. Thus four blood groups are possible, and following the nomenclature of Moss, used in most of the hospitals in Great Britain, they are I (AB), II (A), III (B), IV (O). Jansky's nomenclature, in which the groups are I (O), II (A), III (B), IV (AB), has been adopted on the Continent and by many scientists in Great Britain, and dangerous confusion is liable to arise until one or other is discarded (see Vol. II, p. 532).

*Bauer's
hypothesis*

Although there is no doubt that the agglutinogens are inherited on Mendelian lines, there is still uncertainty about their exact relationship. According to K. H. Bauer A and B are determined by dominant genes which are not allelomorphic, but lie in homologous chromosomes, and O is the double recessive. A person AB marrying one who is O should have children, half A and half B, if A is on one homologous chromosome and B is on the other; but actually, when 474 children of 174 such marriages were examined, about 5.5 per cent were O and 5.9 were AB, the rest being about equally divided between A and B. This is explicable on the supposition that there is an 11 per cent cross-over, the chromosome carrying A becoming entangled with that carrying B, so that when they separate the part carrying one of these genes is interchanged with the part carrying its recessive allelomorph. This results in one chromosome carrying both A and B and its homologue carrying neither, and accounts for the 11 per cent of unexpected AB and O children.

*Bernstein's
hypothesis*

The alternative hypothesis, which has received more general acceptance, is that of Bernstein, who regarded O, A, and B as triple allelomorphs, their genes occupying the same locus on the same pair of homologous chromosomes, so that only two can be present on the homologous chromosomes in the same individual, O and A, O and B, or A and B.

*M and N
agglutinogens*

Landsteiner and Levine discovered two other agglutinogens, M and N, in human red corpuscles, but there appear to be no corresponding agglutinins in human sera. M and N are quite distinct from A and B, and the genes by which they are determined lie on a different pair of autosomes. They are allelomorphs, and consequently three blood groups are possible, MM, MN, and NN.

Work on animals makes it probable that other agglutinogens of a similar kind exist, and, if genes determining one or more of them can be found on each of the twenty-three autosomes and the X-chromosome, this will provide a means of finding out which normal and abnormal characters in man lie in the same chromosome and so of making a complete chromosome map. One result of this will be that the discovery

of linkage between one of these serological reactions and a morbid condition in man will make it possible to recognize in infancy the predisposed members of a family.

4.—INHERITANCE IN TWINS

670.] A fascinating insight into the inheritance of a constitutional weakness in some special organ or tissue is obtained from a study of disease in uniovular twins, who, being the result of the union of one spermatozoon and one ovum, have an identical or closely similar genetic constitution. In one case twin boys developed in both lungs extensive lesions due to congenital syphilis; another pair of twins with a positive Wassermann reaction had attacks of paroxysmal haemoglobinuria when exposed to cold, and a third pair of male twins had general paralysis of the insane at the age of thirty and died within three months of each other.

*Disease in
uniovular
twins*

Fibroadenoma of the left breast has been recorded in one pair of uniovular twins—in both of whom it first became apparent at the age of twenty-one in the same part of the breast; moreover the microscopical appearances of the tumours were identical. Adenocarcinoma has been recorded in another pair. Some time ago I described twin boys, aged 13 years, who suffered from lenteric diarrhoea and abdominal pain, which started at the same date, followed a very similar course, and ended at the same time. Borovsky reported twin boys with undescended testes, urethral valves, and dilated ureters. Both had distension of the bladder with overflow, and in both there was albuminuria on the seventh and pyuria on the eleventh day. One died at the age of eighteen days and the other thirty-six hours later.

Neff recorded toxic goitre in female uniovular twins, both of whom had a high basal metabolic rate, and there are many examples of diabetes mellitus in twins, often starting at the same age and following a similar course in each member of the pair. Michaelis recorded male twins with diabetes, both of whom had renal disease as well and died of uraemia at the age of sixty. May reported another pair of male twins with diabetes, one of whom died aged thirty and the other a year later, and Curtis published accounts of thirteen other pairs.

Pseudoleukaemia infantum has been recorded in male twins, and aplastic anaemia and paralysis agitans in pairs of female twins. Another pair of male twins, always of low mentality, became mentally deranged and suffered from delusions of a religious nature at the age of 21 years and then developed pulmonary tuberculosis, of which one died at the age of 28 and the other at 29.

Marandon de Montyel described twins with marked physical and psychological resemblances, who developed colds, an intestinal derangement, measles, mumps, and varicella during childhood, the diseases always occurring simultaneously in both and their symptoms being almost exactly

*Illustrative
case*

the same. They married and lived in different districts, but became pregnant at the same date, and at the fourth month of pregnancy each had an attack of acute mania with hallucinations, thinking she saw the Virgin Mary and the Devil, and that the latter lifted her clothes and got into bed with her. Each feared she would have a little devil as her child. Their children, boys, were born at an interval of forty-eight hours, after which they improved and in less than a month recovered.

These examples show the remarkable constitutional resemblance between uniovular twins, which extends to their mental processes, their physical response to inborn or acquired diseases, and their immunological reactions.

Structural abnormalities

There are innumerable instances of structural abnormalities occurring in both members of a pair of uniovular twins, such as cleft palate, spina bifida, patent ductus arteriosus, congenital pyloric stenosis, polydactyly, anencephaly, phocomelia, cyclopia, pseudo-hermaphroditism, hypospadias, epispadias, epiloia, and inguinal hernia.

Psychological resemblances

Quite as remarkable as the physical are the psychological resemblances. Many examples of the extraordinary similarity in the mental processes of uniovular twins were collected by Galton, and the resemblance is no less close in those cases in which mental disease has been inherited. Stories of *folie gémellaire* are not uncommon in the literature, and schizophrenia and manic-depressive insanity in particular afford numerous examples of how a mental disease, when it affects a pair of uniovular twins, takes the same course in each. The disease often starts at the same age, hallucinations and delusions are often almost the same, and suicide may be committed in the same way, in spite of the fact that in some cases the twins have lived in a different environment and have had no communication with one another for many years.

Genetically different uniovular twins

On the other hand exceptional cases occur, in which one member of a pair differs genetically from the other. For instance Nettleship recorded a pair of uniovular twins, one normal and the other with red-green blindness; and in more than one instance one twin has had schizophrenia and the other been normal. Somewhat similar is the case of the pygopagus, Mary and Margaret, who had one chorion, and an umbilical cord which was single for the first part of its course. Though they were undoubtedly monozygotic, the pattern on the right sole of Mary was totally different from that on the left sole and on the two soles of Margaret; these three, however, closely resembled one another.

Such cases may be compared with somatic mosaics in insects, birds, and mammals, some of which have a recessive character on one side and a dominant one on the other. This phenomenon is rare in man, but as an example may be quoted an infant whose skeleton on the right side showed all the characters of achondroplasia and on the left side was normal (Nathanson).

Assuming that such twins are monozygotic, at least three explanations are possible. The differences may be due to loss of an autosome during the first or at some subsequent cleavage division; or to non-

disjunction—two homologous autosomes remaining attached to one another so that one cell receives both and the other receives neither; or possibly to the occurrence of a somatic mutation. If the individual is heterozygous for a character, a recessive mutation of the gene for the dominant character would allow the recessive character to become manifest; and if it took place just after the first division of the fertilized ovum, one twin would be heterozygous and the other a homozygous recessive. The result would be similar if the individual were a homozygous recessive and the mutation were dominant. Mutation at this stage would produce twins like those recorded by Nettleship (see p. 466), but it would have to take place later to produce the condition found in the pygopus.

The comparative study of uniovular and binovular twins, though it can throw no light on the mode of inheritance, is essential to a proper understanding of the constitution of man. It is the best way of deciding how much is due to heredity and how much to environment in the case of common diseases.

*Value of
twin studies*

5.—CONSTITUTION

671.] Constitution is defined by Crew as 'the sum of those chemical, immunological, physical, physiological, and psychological peculiarities exhibited by an individual in relation to his environment, or by different tissues or functions in relation to one another'. However sound a man may be, his environment may be so unfavourable that he may break down physically, mentally, or in his immunity to infection; but the man who has inherited a constitutional weakness is likely to break down under conditions which would not have any such adverse influence on the majority of his fellows. Most of the common diseases are caused by two factors—namely, an inherited constitutional weakness and an unfavourable environment; in some cases the former, and in others the latter, is the more important. In very few is the inborn factor the sole cause.

Definition

During the past two decades various attempts have been made to classify mankind into types, each with a special configuration of the body. Kretschmer (1921) described three main types, the asthenic or leptosome, the pyknic, and the athletic. The asthenic type is tall and slight with a long flat thorax, narrow drooping shoulders, and poor musculature; the pyknic is short with a broad deep thorax and short neck, and is apt to deposit fat in the face, neck, abdomen, and buttocks; and the athletic is of medium height with broad thorax, neither very deep nor flat, broad square shoulders, powerful musculature, and large hands and feet. The pyknic is the digestive, the athletic is the muscular, and the asthenic includes both the respiratory and the cerebral types described earlier by Sigaud and adopted by the French school. According to Draper (1924) recognition of the types by the eye is misleading

*Kretschmer's
classification
of human
types*

and should be arrived at by taking a large number of measurements, using bony points as landmarks. He emphasized the value of these measurements in clinical medicine, for when there is doubt about a diagnosis the type to which a person belongs may be the means of arriving at the correct decision. On the whole, however, his classification and Kretschmer's agree. Both agree also that the types are not sharply differentiated and that many intermediates occur, Kretschmer stating that the types exist in all races.

Attempts have been made to show that each of these types has a special liability to certain diseases. It is said that the asthenic type is prone to pulmonary tuberculosis and peptic ulcer, the pyknic to manic-depressive insanity and apoplexy, and the asthenic and athletic types to schizophrenia. According to Hurst, however, gastric ulcer occurs chiefly in the asthenic type, and duodenal ulcer in the pyknic type.

*Heredity of
Kretschmer's
types*

The three types are undoubtedly due to hereditary factors and, though the conformation of the body like almost all normal characters in man is the result of a number of factors, it is probable that one gene plays the principal part in determining each of the main types, other genes perhaps causing various minor modifications and so producing intermediates of different kinds. The diseases to which these types are said to be prone are for the most part determined by more than one gene; or they are in part due to extrinsic factors; or both genetic and extrinsic factors are concerned. Schizophrenia and manic-depressive insanity probably belong to the first class and peptic ulcer to the second; in tuberculosis there is more than one gene which confers immunity, and exposure to infection is an important extrinsic factor.

Presumably the explanation of the liability of persons belonging to one of these types to suffer from a particular disease is that the principal gene determining the type lies on the same chromosome as one of the genes determining the disease, and the phenomenon is in the main one of linkage.

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HERMAPHRODITISM

See FOETUS DISEASES, Vol. V, p. 366; and
UROGENITAL ORGANS, ABNORMALITIES

HERNIA

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Reference may also be made to the following titles:

ABDOMINAL PAIN AND ACUTE ABDOMINAL
EMERGENCIES
DIAPHRAGM DISEASES
INTESTINAL OBSTRUCTION
PERITONEUM, NON-INFLAMMATORY DISEASES

I.—DEFINITION OF ALL TYPES

(*Synonym.*—Rupture)

672.] The term hernia is applied to the protrusion, or passage beyond its normal limits, of some portion of the contents of one of the body cavities. When used without qualification the term is understood to mean external abdominal hernia. There are also internal herniae which, properly speaking, are intrusions of abdominal contents into a pouch or foramen inside the peritoneal cavity; these herniae will be described under the title PERITONEUM, NON-INFLAMMATORY DISEASES.

*Internal
hernia*

Other types of hernia concern the chest cavity—hernia of the lung, or the cranial cavity—hernia cerebri. Sometimes a structure normally confined by a special sheath or capsule bursts its bounds giving rise to such conditions as 'hernia testis' or 'hernia of muscle'.

II.—EXTERNAL ABDOMINAL HERNIA

I.—AETIOLOGY

(1)—Frequency

673.] Hernia is very common, especially among those engaged in laborious occupations. The examination of recruits during the War 1914-1918 showed that about 2 per cent were affected by some type of hernia.

Incidence

Inguinal hernia probably accounts for 82 per cent of the total, incisional or post-operative 8 per cent, femoral 4.5 per cent, umbilical 3.8 per cent, epigastric 0.7 per cent, and the other very rare varieties 1 per cent (Seward Eirdman).

(2)—Causation

Association with normal apertures

All the usual varieties occur either in situations where there are apertures for the passage of blood-vessels and other structures through the abdominal wall, or where such passages have existed in foetal life.

Inguinal hernia

Persistence of processus vaginalis

Inguinal hernia is intimately associated with the descent of the testicle. Since the time of Percivall Pott it has been known that many of these herniae depend on persistence of the processus vaginalis of peritoneum which precedes the descent of the testis into the scrotum; the occlusion of this process may be delayed into post-natal life, and when it remains patent in its entirety the 'congenital hernia' may follow. Even when it is apparently completely obliterated a slight depression may persist over the abdominal aspect of the inguinal region and the femoral canal; this really represents a congenital defect and is probably the beginning of the sac in many cases. It is assumed that increased intra-abdominal pressure directed to these areas may gradually stretch and enlarge them, producing a hernial sac. This is the saccular hypothesis of Hamilton Russell and is held to explain most herniae said to be acquired. But there may be some added weakness or abnormal disposition of the muscles guarding the inguinal canal. The abnormal intra-abdominal pressure may be gradual and increasing or dependent on some violent effort.

Traumatic

In extremely rare cases a very definite and severe injury with local signs of trauma is followed by the rapid development of hernia; but apart from this, the true traumatic type, the relation of accidents to the production of hernia is equivocal and often indeed the cause of much litigation. When a hernia descends into the scrotum immediately after an accident, whether a blow or a strain, it seems certain that there must have been a pre-formed sac into which the intestine has entered. It is, however, conceivable that a blow or severe strain might

rupture the peritoneum in the inguinal region and a hernia thus develop. But in that event there would be signs of local trauma, if not at once certainly within forty-eight hours, and the bulging and development of the hernia would follow only slowly after. If there is litigation the onus of proof would seem to fall on the claimant. The origin of incisional hernia is obvious.

*Incisional
hernia*

Hernia through the linea alba and the linea semilunaris may be due to the protrusion of a small mass of extraperitoneal fat which, in its growth, draws a pouch of peritoneum after it through the parietes. The pull of such a lipoma may explain the production of hernia in other situations and is a possible cause of the direct inguinal variety.

*Lipoma
hypothesis*

Experimentally, endocrine disturbances have been shown to play a part in the production of hernia in rats, and possibly they may be a factor in the human subject.

*Relation to
endocrine
disturbances*

2.—SOME ANATOMICAL FEATURES

(1)—The Sac

The peritoneal pouch—known as the sac—into which the herniated parts find their way is very thin in congenital and in recent herniae; in long-standing herniae it is often thick and tough, but in spite of this may be torn as the result of rough manipulation.

The sac has usually a definite fibrous narrowing, the so-called neck, at the point where it originated from the parent peritoneal cavity. In hernia of some duration this neck is often pushed further on, so that there is a funnel of peritoneum above it forming an intermediate channel between the peritoneal cavity and the neck proper. This is the part that should be exposed and tied when the sac is removed by operation.

The neck

The inner surface of the sac is usually smooth and glistening but may be roughened as if from previous inflammation, even though the history may be silent on this point. Between the sac and its contents there may in these cases be adhesions, which are firm, strong, and vascularized, in contrast with the flimsy adhesions which may follow recent inflammation or strangulation. As a consequence there may be other narrowings in the sac in addition to the neck proper. The rounded extremity of the sac is known as the fundus.

Inner surface

Adhesions

The sac may be quite dry or contain some serous fluid. Sometimes the neck or one of the narrowed areas in the sac may be obliterated or blocked by a plug of adherent omentum. When this occurs the sequestered part is usually filled with clear fluid and is known as 'hydrocele of a hernial sac'.

Fluid in sac

In the course of its extrusion from the abdomen, the sac carries with it coverings of all the structures through which it passes. These coverings are intimately adherent to one another and to the sac but can be easily separated from the latter when the proper plane of cleavage is found.

*Coverings of
sac*

(2)—Contents of Sac

The contents of the sac are usually omentum, or small intestine, or both, and such an amount of fluid as is normal in the peritoneal cavity. But any of the movable viscera may be present. Even the solid organs may, though rarely, pass into a hernia, with perhaps the exception of the pancreas. Naturally the contents vary with the type of hernia and with the sex. The relation of the vermiform appendix to hernia is referred to later (see p. 504).

(3)—Portal of Exit

The portal of exit from the abdomen may not show any abnormality; the inguinal canal for instance may preserve its valve like mechanism intact. On the other hand, as the result of the dilatation of a persistently filled hernial sac, the openings may be stretched and their muscular boundaries may lose their tone; or the muscles and fibrous structures may be abnormally flabby or even show atrophy.

(4)—Reducible and Irreducible Herniae

A hernia may be wholly or partly reducible, or it may be irreducible, the contents being retained in the sac by reason of their bulk, or by a constriction at its neck, or by adhesions.

3.—CLINICAL PICTURE AND DIAGNOSIS**(1)—The Symptoms Common to Herniae**

As a rule the patient notices some discomfort which draws attention to the part in which an abnormal swelling is found. Such a swelling may be present only intermittently, and in the early stages of its development usually disappears when the patient lies down.

Often there is a feeling of weakness or insecurity in the hernial region, and the patient may instinctively support the area with the hand or by leaning against some object, such as a desk or table. There may be stretching or bursting pain, but these troubles characteristically disappear on lying down. Some patients are unconscious of their disability and, when complications arise, may not associate the symptoms with the presence of a rupture; this especially applies to small femoral herniae and more than justifies the rule which demands that *in all doubtful abdominal conditions the hernial sites should be examined*.

Onset

The onset of herniae varies. Some are present from birth, others suddenly appear later in life, perhaps after a strain, whereas others appear gradually and are first recognized as an unusual swelling or lump. Sometimes a hernia comes down for the first time into an empty congenital sac and is at once strangulated. This sequence of events is more usual in young adults, but it may happen in the aged.

Once it has appeared, a hernia tends to become progressively larger

though not necessarily more troublesome. Very rarely, even in an adult, it may spontaneously disappear. Often it is the small incipient hernia that is associated with most local discomfort and pain, in contrast with some cases of large fully developed hernia in which these symptoms are entirely absent. As a rule hernia is associated with discomfort rather than pain, though colic and slight nausea often occur when the hernia is down. Sometimes the pain and discomfort are not referred to the hernia, but there is dragging pain about the umbilicus, or a pain in the back described as 'lumbago'.

Pain and discomfort

Referred pain

A hernia may cause constipation or dyspepsia; or the only complaint may be of the inconvenience or unsightliness of the local swelling.

The associated discomforts are often an index of the nervous susceptibility of the patient, those who complain most being often of the neurotic type.

Very often patients blame the condition for whatever symptoms they may suffer from; for instance an adult who has endured a hernia for many years will complain of deterioration in general health or some unusual discomfort and make up his mind that the chronic hernia must be the cause and requires operation. It is not unnatural that the patient's attention should be focused on the external and obvious condition, but often the cause of the symptoms must be sought elsewhere; it may be a carcinoma of the stomach or colon, or prostatic enlargement with renal insufficiency; in females with umbilical hernia attacks of pain may really be due to gall-stones. It follows that very careful consideration should be given to the symptoms for which patients seek advice, especially when the condition is of long standing.

(2)—General Signs

An abdominal hernia forms an external swelling which if uncomplicated is soft and compressible. When the hernia can be returned to the abdomen the process is usually accompanied by a gurgling of intestinal gas and liquid which may be felt as well as heard. It gives an impulse on coughing which can be seen, and it conveys to the examining fingers a sensation of propulsion, which is expansile if the hernia contains intestine.

(3)—Examination of Patient

The patient should be examined both standing and lying. The size and tension of a hernia in the erect patient are often an unexpected revelation. The build and muscular condition of the abdominal wall can best be determined in this position.

Patient standing

In the recumbent patient the size and condition of the hernial orifice can be determined. The readiness with which the hernia descends and the force with which it bulges yield information about the patency of the orifice and the strength of the diaphragm. Special care should be taken to examine the sac after its contents have apparently been completely reduced, as it may then be possible to detect some portion

Patient recumbent

of omentum which remains attached to the sac and which may have a considerable bearing on the management of the case. The other hernial sites must also be examined.

General examination

In the general examination which is always necessary the condition of the urine and the importance of the renal function must not be overlooked, especially in the elderly.

(4)—Complications

(a) *Obstruction*

When a hernia is irreducible it may become obstructed in the sense that the contents of the bowel in the sac do not pass on. The only symptom when the sac contains part of the colon may be obstinate constipation; vomiting and constitutional disturbance may be absent, but there may be some colic, and palpation may show that the bowel is packed with masses of faeces. The condition may often be relieved by purgatives and enemas assisted by manipulation of the hernia.

(b) *Strangulation*

In the days when any form of operative interference was associated with a high mortality, much ingenuity was exercised in attempts to differentiate between inflamed, incarcerated, and strangulated herniae. Now when operation is infinitely safer than delay, it is much wiser to regard any complication as potentially strangulation and to settle the matter by surgical exploration.

Incidence

In true strangulation, which occurs in about 25 per cent of femoral, 15 per cent of umbilical, and 3 per cent of inguinal herniae, and is one of the commonest causes of acute intestinal obstruction, there is interference with the vascular supply of the hernial contents.

Symptoms

Onset

This complication is usually heralded by an attack of pain, at first referred to the umbilical region and later felt in the hernia. The onset may be as sudden and acute as that of any abdominal emergency but is usually more gradual. When it is sudden the pain may be accompanied by collapse and vomiting; when it is gradual there is no collapse, and vomiting is delayed. Whatever the type of onset, the early vomited matter consists of the gastric contents and is in no way typical.

As the first seizure passes off it is followed by intermittent colic, sometimes with great desire to defaecate or to pass flatus. As in all forms of intestinal obstruction the bowels may act in the early stages but without relief. As the condition progresses the vomit recurs and characteristic colic follows the spasms of colic.

*Signs of
toxaemia*

Coils of contracting intestine may be seen and felt and the abdomen gradually becomes distended. Attempts to take food bring on colic and vomiting. The condition of the patient deteriorates and this is reflected in the drawn facial expression, the dry tongue, and other evidences of toxaemia. For some hours the pulse is little affected, but steadily and slowly its rate rises and it becomes softer. The temperature is not usually raised and in the later stages may be subnormal.

Locally the hernia is usually larger than it has ever been before; it is tense and slightly tender and cannot be reduced by any effort of the patient. In the later stages the skin may be reddened and oedematous. *Local signs*

Attempts to obtain an action of the bowels by medicines and enemas fail, though in a few cases the bowels act but without relieving the symptoms or influencing the local condition. These are probably examples of partial enterocele (Richter's hernia, see p. 507).

In some cases the patient does not mention that he has a hernia and indeed may not be aware of its presence, referring all the symptoms to the abdomen. Such patients do not complain of anything except attacks of pain followed by uncontrollable vomiting, and usually attribute their symptoms to an acute stomach upset.

The vomiting is characteristic in that it is very easy and occurs without nausea. It is often propulsive, the vomited material shooting out of the mouth without any conscious effort on the part of the patient. The material gradually alters and from gastric contents soon becomes yellow with an unpleasant smell; this in turn is followed by the dark brown horribly offensive faecal vomit peculiar to the late stages of obstruction. *Nature of vomit*

The rate of progress of strangulation varies considerably. In young adults especially it may be very rapid, and in forty-eight hours the condition may be fully developed and one of serious toxæmia. In others, particularly the aged, the progress is much slower, and it may be a week before the same stage is reached. Some few cases go on to abscess formation in the sac and the development of a faecal fistula. If the latter happens to be low in the bowel it is not inconsistent with survival for many years. *Rate of progress of strangulation*

(c) *Local Trauma*

Rupture of intestine within the sac has occasionally been produced by severe strains or by accidental twisting of the body; it is very rarely due to direct violence.

(d) *Pathological Conditions involving Hernial Sacs*

As a hernial sac is only a cul-de-sac of the peritoneal cavity, pathological conditions affecting the latter—e.g. peritonitic effusions, tuberculosis, and malignant disease—may involve the sac by direct extension. Tuberculous infection of the sac is not uncommon in young children and causes a characteristic doughy thickening. Nodules of malignant growth may be detected and their nature suspected even before there is any other evidence of the site of the primary malignant disease in the abdomen.

4.—TREATMENT

(1)—General Treatment of Hernia

Broadly speaking the treatment involves either mechanical retention of the hernia by some sort of apparatus, or its repair by operative interference. The first plan is palliative; the other aims at cure.

(a) *Palliation by Truss*

The question is often asked: Does retention by a truss ever cure hernia? The only criterion of cure is obliteration of the sac. In children, if the hernial sac can be kept empty, its lumen may become obliterated, but there is no certain method of determining that this has been accomplished. When a truss has been worn for a time there may be no sign of hernia, and it may be impossible to bring it down by coughing or straining; none the less in many such cases the hernia recurs, perhaps after many years, and then usually descends completely into the scrotum, proving that though the sac has been empty it has not become obliterated.

*Indications
and contra-
indications*

Only herniae that are completely reducible can be controlled by truss treatment. The smallest tap of omentum adherent in the sac will facilitate the descent of other abdominal contents and render treatment by a truss unsatisfactory. To have a chance of success a truss must retain the hernia in all positions of the body and in the presence of ordinary stresses such as coughing, sneezing, and laughing. The real test of a truss is its ability to retain the hernia while the patient sits on the edge of a chair with the trunk bent fully forward and the legs widely separated. If in this position the hernia is retained during coughing the truss is likely to prove efficient.

*Measurement
of patient
for truss*

In ordering a truss the circumferential measurement of the pelvis should be given. The tape measure is passed round the body midway between the anterior superior spine and the top of the great trochanter, the measurement being made from the summit of the hernia back to the same point. The side and type of the hernia and the strength of spring required must be stated. The object of a truss is to prevent the hernia from ever coming down; it must therefore be applied before the patient rises in the morning and not be removed before he lies down at night. A special washable truss must be used for the bath.

*Relief of
discomfort
from truss*

The discomfort usually felt when a truss is first fitted may be minimized by hardening the skin over the points of pressure with surgical spirit and then dusting the dried skin with a powder of chalk or talcum and zinc oxide.

The wearing of a truss may, by affording relief, prove that the hernia was in fact the cause of the patient's symptoms. A period of truss treatment need not interfere with the success of any subsequent operation.

(b) *Operation*

*Aims of
operation*

The ideal treatment for hernia is one which will safely obliterate or remove the sac and, by strengthening the boundaries of the region, prevent its re-forming. For many years this result has been achieved with considerable success by open operation.

*Sclerosing
injections*

Recently, however, the old and frequently revived method of treatment by sclerosing injections has been tried once more. Its immediate successes have often been striking, but recurrences have tended to occur

after about six months. In recent years Piña Mestre of Barcelona and other surgeons have used the treatment in thousands of cases, and it should soon be possible to determine its value by a study of the long term results. (For details of this method see p. 480.)

In most cases open operation is the method of choice. It has very few absolute contra-indications, but in certain circumstances the pros and cons must be carefully weighed; in the subjects of a mortal disease it must not be considered except in the presence of strangulation. Nor should it be employed in persons with haemophilia, an absolute contra-indication, diabetes mellitus, unmanageable cough, or great or increasing obesity, because accumulating fat will break through any known barrier. Operation is also contra-indicated when the hernia is so large that the abdomen cannot accommodate the added contents (see also p. 500). Old age is not in itself a contra-indication, but combined with general feebleness and poor nutrition of the tissues it may render the outlook too unpromising to make operation worth while.

*Open
operation
Contra-
indications*

The mortality of the radical cure in all types (i.e. not excluding large umbilical and ventral herniae and other bad risks) is less than 1 per cent. This must be contrasted with a mortality of between 15 and 20 per cent following operations in strangulated herniae of all types.

Mortality

To reduce risks to the minimum a careful preliminary examination must be made of all cases that are to be submitted to operation. It is especially important to postpone intervention when there is evidence of respiratory infection, because most of the few deaths are caused by pulmonary complications.

The after-results of operative treatment vary with the type of hernia and the condition of the subject, but in many cases the burden of hernia is so distressing that an operation may be worth consideration even if it cannot do more than render a large hernia amenable to support by a properly fitting truss.

After-results

Statistics as to the after-results vary widely; there is, for instance, a great gulf between the figures of Coley and Huguët (1918), who found only fourteen relapses among 3,725 cases of inguinal hernia operated upon by the Bassini method, and those published by Max Page (1934), who found 20 per cent of recurrences in indirect hernia and 25 per cent in the direct variety among London policemen. But the figures of individual operators are less startling, the recurrence rate being about 5 per cent in the indirect and 15 per cent in the direct variety of ordinary inguinal hernia, 3 per cent in femoral hernia, and 20 per cent in umbilical hernia. A large proportion of the recurrences occur within the first six months and nearly all within the two years immediately following operation. These figures do not justify complacency and suggest that the operation should be restored to the category of major procedures which should not be left to house surgeons or other inexperienced persons. The patient's best chance lies in the primary operation, those for recurrence never holding out the same prospect of success.

*Statistical
results*

Recurrences

*Time of
recurrence*

*(c) Injection Treatment**Indications and contra-indications*

This method is unsuitable for use in children or in cases complicated by imperfect descent of the testicle. For the most part it has been used for inguinal hernia, and it is essential that this should be completely reducible and capable of being controlled by a truss.

Advantages

The advantages claimed are: (i) that the method is ambulatory and suitable for out-patient practice; (ii) that the patient can continue at work; (iii) that pain is very slight and general anaesthesia unnecessary; (iv) that the fear associated with a cutting operation is obviated; (v) that injection may be successful when operation has repeatedly failed; and finally (vi) that it does not preclude the possibility of operative treatment later should this prove necessary.

Dis-advantages

The disadvantages are: (i) the multiplicity of the injections which may have to be continued over several weeks; (ii) the possibility of infection with subsequent gangrene; (iii) the risk of plastic peritonitis with resulting intestinal adhesions; (iv) the occasional persistent swelling of the scrotum; and (v) the uncertainty of the results in the present state of knowledge.

Technique of injection

The method to be described is that advocated by G. B. Delisle Gray, who attributes it to Ignatz Mayer of Detroit, U.S.A. Obviously it should be used only by those who are scrupulously careful in carrying out the details.

It is essential that the injection should not be made into the sac but round its neck and between the layers of the muscles bounding the canal. The spermatic cord does not appear to be injured by the subsequent contraction of the scar tissue. A truss of the spring pattern capable of exerting continuous pressure must be worn continuously throughout the treatment and for some time afterwards.

Solutions used

Many solutions have been employed; Mayer's formula, recommended by Delisle Gray, is as follows:

Zinc sulphate	—	—	—	—	1 drachm
Phenol crystals	—	—	—	—	6 drachms
Glycerin	—	—	—	—	4 fl. ounces
Cinnamon water	—	—	—	—	1 fl. ounce
Liquid extract of hemlock spruce	—	—	—	—	5 fl. drachms
Sterile re-distilled water	—	—	—	—	2 fl. ounces

The compounding of these ingredients should be carried out by a skilled chemist. The ready prepared solution can be obtained under the name obturatin. For the first injection 0.5 c.c. is used, and for subsequent injections 1 c.c.

*Dosage**Position of patient*

The hernial region is shaved and cleaned with spirit or iodine. The patient lies on the back with the buttocks raised on a folded pillow and is instructed to remain entirely passive. The hernia must be fully reduced.

The injection is carried out as follows: (1) The scrotum is invaginated

through the external ring in order that the external oblique muscle may be lifted forwards. (2) The needle (size No. 17) of the charged syringe is inserted vertically over the site of the internal ring until its point is felt to pierce the aponeurosis. (3) Before making the injection the plunger of the syringe is withdrawn to ensure that no considerable vessel has been entered. (4) The injection is then made slowly, the needle being moved from time to time. (5) The syringe is withdrawn and the area dusted with talc powder. The truss is reapplied before the patient rises from the couch and must on no account be disturbed until the time of the next injection. When the hernia is so small that the scrotum cannot be inverted, the needle is inserted directly into the region of the internal ring which is situated half an inch above the centre of the inguinal (Poupart's) ligament.

*Technique
of injection*

The injections are repeated every four to seven days depending upon the degree of reaction. After a few injections a hard mass forms deep in the inguinal region. At the end of a month the injections are discontinued for a fortnight, the truss still being kept in position. It is then removed with the patient lying down, and he is asked to cough; if there is no impulse the patient is examined again in a fortnight, this time in the erect posture, and if again there is no impulse the truss may be discontinued, at first at night only but after another month altogether except during severe exertion. During the period of treatment there is seldom much pain, but there may be a bruised feeling with some aching; and there may be sensations of heat referred to the genitals and the perineum. These symptoms soon subside, and the truss must not be removed in the hope of relief.

*Repetition
and
continuation
of injections*

From ten to thirty injections may be necessary, the average being about twenty. The treatment continues over a period of from three to six months.

*Duration of
treatment*

(d) *The Use of Living Fascial Sutures*

This method, which was introduced into the surgery of hernia by Gallie and Le Mesurier, established a new principle in the operation. Not only do the fascial strips act as sutures but they become incorporated with the living tissues and remain as permanent additions to the region where they are introduced. They further stimulate the growth of new and strong fibrous tissue.

Thus they may be used to build a barrier of new tissue in the space between structures that cannot be brought into apposition. They may also reinforce ordinary sutures when the tissues are obviously poor or in cases in which recurrence of hernia has shown that the tissues cannot be relied upon to heal soundly. The existence of this state of the tissues is shown by the fact that, in some few cases, herniae which have been thoroughly repaired by experienced surgeons may recur almost at once.

Indications

The fascial strips can sometimes be obtained from neighbouring structures such as the tendon of the external oblique muscle (Andrews). When longer or large numbers of strands are required, the fascia

*Source of
fascial strips*

lata on the outer side of the thigh provides a source from which half a dozen or more strands, $\frac{1}{8}$ inch wide and 1' or more inches long, may be conveniently procured. The fascia may be exposed through a long incision on the outer side of the thigh, so that the strips may be cut under the guidance of the eye; or, if a fascial stripper is used, incisions only about an inch long need be made, one at each end of the strip to be removed. Gallie and his co-workers prefer the open method, which

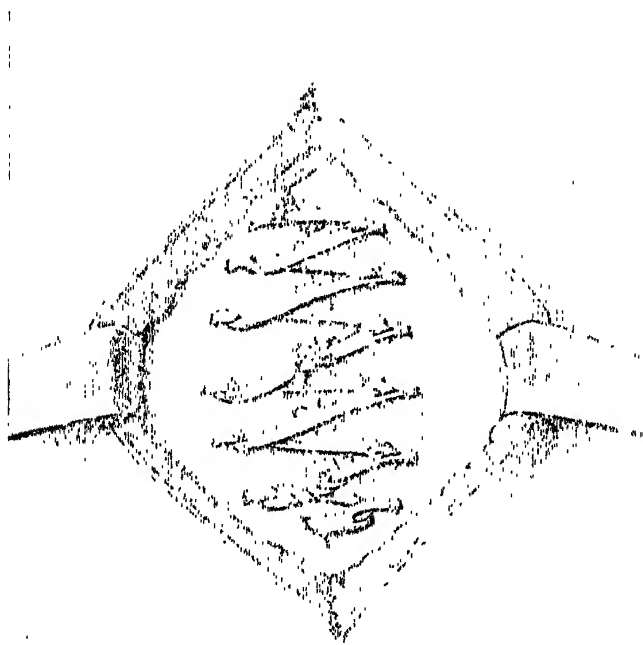


FIG. 73.-- Use of fascial sutures for repair of incisional hernia by Gallie's method. (From *Modern Operative Surgery*, edited by G. Grey Turner)

has the advantage that the defect in the fascia can be repaired (see Fig. 73). When this step has been omitted some patients have complained of slight weakness of the limb and have exhibited a mild limp. A special needle is required for the introduction of the fascial sutures.

It is not suggested that the living sutures are necessary in all cases, but they have proved most useful in dealing with herniae of the direct type, large ventral herniae, and, especially, recurrent herniae. Great care must be taken with the technical details and especially to anchor carefully the ends of each strand. Even in the presence of mild infection the strips have often fulfilled their purpose with complete success. But it is manifestly absurd to suppose that the mere use of these living sutures provides a panacea, and every care must be taken to carry out the

essential steps in all hernia operations. With characteristic candour the originators of the method have published the details of a series of failures which emphasize the need for care in its application

(2)—Treatment of Strangulation

Radical treatment is ultimately imperative, because a hernia which has been strangulated may become so again; but an immediate operation for its repair is not necessarily called for. In some cases, however, the only chance of getting a very necessary operation performed is to seize the urgency of strangulation as an opportunity.

(a) *Reduction by Manipulation (Taxis)*

At the outset of this complication and for about four hours afterwards, reduction by manipulation (taxis) may be attempted, provided that it is clearly understood that if it fails operation becomes most urgent.

Taxis should only be carried out in as favourable circumstances as *Technique* possible, for example, with the patient warm in bed. The nature of the intended manipulation should be explained, so that a favourable psychological atmosphere may be created. If there is great pain or the patient is of an irritable temperament, morphine should be administered and a reasonable time—about half an hour—allowed for it to produce its effect. The patient must lie flat on the back with a pillow raising the buttocks; the lower limbs should be flexed on the abdomen, with the thigh on the same side fully adducted if the hernia is inguinal or femoral. The practitioner then steadies the region of the neck of the hernia with one hand and with the other gently compresses and impels the body of the hernia upwards and outwards, the aim being to move the contents back into the direction from which they came. This direction is upwards and outwards in cases of inguinal hernia. For variations in the path of femoral hernia see p. 491.

In very large inguinal herniae it is often advisable to delay taxis for a short time; the patient is kept in bed with the foot elevated as high as possible, a small dose of morphine is given, and an ice bag or a hot fomentation is applied to the hernia. This plan often succeeds in bringing about spontaneous reduction, but, if not, taxis may be tried after an hour or so. Should this also fail, immediate operation is imperative; indeed, it is unwise to attempt taxis under anaesthesia unless arrangements have been made to proceed at once to operation.

If reduction by taxis is successful, the patient is usually completely *After-history* relieved, and very often the bowels act almost at once. On the other hand, although the pain and vomiting may cease, the bowels may not act, abdominal distension and cessation of intestinal movements indicating that paresis *Paresis* has supervened. This usually passes off spontaneously in twenty-four to forty-eight hours, but sometimes it does not do so and may be the cause of death after successful reduction by operation as well as by taxis.

Manipulation sometimes forces a small hernia into the extraperitoneal

'Reduction en masse'

tissue without relieving the strangulation. This 'reduction en masse', though very rare, is a real danger, because the disappearance of the visible lump may produce a totally unfounded sense of security while the symptoms continue, sometimes in an aggravated form. The same result may be brought about by patients themselves 'auto-reduction en masse' especially by those who have been accustomed to reduce their own ruptures satisfactorily. The only treatment is by operation.

'Auto-reduction en masse'

(b) Operation

Many patients are not seen until late, when there can be no question of trying taxis. In such cases an operation should always be performed, for it is remarkable how often an apparently moribund patient will respond to minimal operative interference.

Scope of operation

The operation of herniotomy aims at the relief of the strangulation, not at radical cure; but in practice the patient's condition is often sufficiently good to allow the radical cure to be included. On the other hand, there have been many fatalities because it was erroneously supposed that the complete operation was justified.

Anaesthesia

General anaesthesia should not be used in the presence of repeated vomiting, on account of the grave risk of infection of the lungs by aspirated vomit. Any operation for strangulated hernia, whatever its magnitude, can be carried out under local or spinal anaesthesia; if this is not available the stomach must be emptied by tube just before operation, and the tube should be passed again before the patient is moved from the table, as intestinal contents commonly regurgitate into the stomach during the operation.

Stages of operation

The essential steps are: (i) to cut down on the neck of the sac; (ii) to open the sac; (iii) to remove the constriction; (iv) to examine and deal with the contents of the sac; and (v) to conclude the operation as the circumstances of the case and the patient's condition may demand.

Relief of constriction

The constricting structure is usually the neck of the sac, and this is most safely divided by slitting up the sac with scissors towards this point. Usually one blade of a pair of blunt-pointed scissors may be passed through the constriction by the side of the intestine, and if this can be accomplished the constriction may be safely severed. When it is too tight to admit the blade of the scissors a hernia director may be inserted and will provide a safe guide for a hernia knife. At this stage it is most important to draw down the intestine so that its condition at the point of strangulation may be noted.

Condition of gut at point of strangulation

The intestine at this point is particularly prone to be necrotic as a result of direct pressure, although the remainder of the intestine may be quite normal. As a rule the necrotic or doubtful area can be safely buried by a row of interrupted Lembert sutures with a few additional supporting stitches over all. If the site of constriction is not damaged but the vitality of the loop of bowel is doubtful, time must be allowed for its recovery. It is remarkable how often this occurs in a few minutes after the application of gauze soaked in warm saline.

If, on the other hand, normal colour and lustre do not soon return and the vessels in the mesentery cannot be felt to pulsate, resection must be carried out. In these circumstances it is unwise to risk too limited a removal, and the line of section should be made through healthy bowel at least three inches on each side of the damaged area and probably much more on the proximal side. Restoration may be made by end-to-end or side-to-side anastomosis according to the experience of the operator. If the patient is extremely ill the operation may safely be terminated at this stage; it is not essential to remove the sac, which may be left in situ and merely packed with gauze with the assurance that it will eventually heal over, the problem of radical cure being left to a later stage.

Gut requiring resection

In similar circumstances, when the condition of the intestine suggests that necrosis will probably occur, the loop of bowel may be left in the sac after division of the constricting agent. On the other hand, if the condition is not so desperate but the state of the intestine very doubtful, it may be replaced just inside the abdomen and fixed there with a suture.

Other procedures for unhealthy intestine

In either event, if necrosis does subsequently occur, the consequent faecal fistula will open directly into the wound and probably without infecting the general peritoneum. Quite often intestine in such doubtful condition unexpectedly recovers and slowly retracts into the abdomen. Faecal fistula presents a serious problem for treatment, because it only very rarely heals spontaneously.

Faecal fistula

In any case of strangulated hernia the condition of the patient may be so serious that it is necessary, after removing gangrenous intestine, to leave some type of Paul's tube tied in the open ends. As in the cases of spontaneous faecal fistula, the subsequent management presents serious problems and the outlook is extremely precarious.

Inguinal hernia

In inguinal hernia the operation is carried out through an incision over the canal such as would be employed for the radical cure. It should be remembered that the neck must be divided in the upward and outward direction.

Femoral hernia

In femoral hernia the approach below Poupart's ligament suffices for the smaller herniae which have not been long strangulated. In other circumstances the inguinal approach is very much more satisfactory. In either case the incision should be oblique and parallel to Poupart's ligament. The steps of the operation are those already detailed. In this variety of hernia the neck of the sac is much oftener the constricting agent than is Gimbernat's ligament. At all events the neck should be examined in the first instance; it can sometimes be dilated by gently passing the finger up by the side of the intestine and insinuating it through the opening. If the neck is too tight for this manoeuvre to succeed, the sac should be further isolated and drawn down and the

Constricting agent

constriction divided as already detailed. If it is incised without being drawn down, the intestine may be inadvertently reduced through the rent instead of into the abdomen. Such an accident is not likely to occur if the approach is from above. In the rare cases in which the constriction is not produced by the neck Gimbernat's ligament must be mildly incised or nicked in the inward direction. In no circumstances should Poupart's ligament be divided.

Umbilical hernia

Causes of constriction

In umbilical hernia the problem of dealing with strangulation may be very serious. The strangulation is as often produced by the intestine entering loculi in the sac, or by bands or adhesions in the sac, as by the neck. The exact condition cannot be determined until the sac is opened. The interior of the sac is often most safely reached by making an incision into it near the neck and working cautiously upwards towards the summit. Sometimes the sac can be safely opened at the latter point, but the bowel there is very often adherent and may be inadvertently injured.

Treatment of adhesions

The only safe plan is to expose the contents bit by bit, opening up loculi and dealing with adhesions as they are encountered. Sometimes the intestine is so firmly adherent that there is a very grave risk that it will be torn if separation is pursued. In these circumstances it is quite safe to cut away portions of the sac wall, leaving them attached to the bowel and returning the latter in this condition to the abdomen. When the obstruction is produced by kinking and narrowing of a considerable portion of intestine, it is often wiser to perform a lateral anastomosis excluding the obstructed area rather than to persist in the process of separation. Adhesions of the omentum to the sac and its contents may be very formidable, and both time and care may be needed for their separation. Great caution must be exercised in ligaturing off omentum before it is returned to the abdomen. It is unwise to remove large portions of omentum, because this structure is a great protection for the intestines and should be conserved whenever possible.

Adhesion to omentum

Procedure with very large herniae

When dealing with very large herniae it is often wiser merely to relieve the strangulation without attempting removal of the sac and repair the abdominal wall; the sac is then simply closed by suture, and the problem of radical cure left to a subsequent occasion.

5.—TYPES OF HERNIA

(1)—*Inguinal Hernia*

Incidence

674.] In males this is far the commonest variety. It may occur from early infancy to extreme old age and takes two forms: the oblique and the direct.

(a) Oblique Form

The oblique form may be obviously congenital, the sac being formed by the unobliterated tunica vaginalis so that the contents surround the testicle; the modifications known as the infantile and the encysted forms are of academic interest rather than practical importance. When this hernia is said to be acquired it may present as a bulging in the canal (a bubonocoele), but in time it usually descends as far as the testicle and is then known as scrotal hernia. This type may attain an enormous size and, when operation was seldom employed, cases were seen in which the hernia descended as far as the knees.

*Congenital**Acquired*

When the hernia is of moderate size and reducible, the scrotum can be invaginated into the canal so that the spine of the pubes can be felt below and external to the neck of the sac. When the sac is empty it can usually be felt by the side of the cord at the neck of the scrotum, and this may be an important clinical sign in children.

(b) Direct Form

This form is much less common and represents about 25 per cent only of all inguinal herniae. It usually occurs in the rather spare type of subject at about fifty years of age. It forms a rounded swelling just above the pubes and near the root of the penis. Although it presents through the external ring, it rarely descends into the scrotum and is seldom larger than half an orange.

Incidence

The sac leaves the abdomen either just to the outer side of, or directly through, the conjoined tendon. It is globular in shape but has a definite neck; as a rule it is easily reduced and strangulation is very rare.

Differential diagnosis of both forms

The differential diagnosis of inguinal hernia is usually sufficiently obvious.

Testicular swellings, of which the commonest is hydrocele, may give rise to doubt. By careful palpation of the neck of the scrotum it is easy to prove that the swellings, whatever their nature, originate in the scrotum and do not descend from the inguinal canal.

Diagnosis from testicular swellings

Varicocele may simulate hernia, but the condition is nearly always left-sided. Careful inspection reveals the enlarged veins, particularly at the back of the testicle. A familiar test is to apply digital compression over the external ring with the patient recumbent, maintaining the compression when he stands up; if the condition is varicocele the scrotal swelling will return, the veins filling from below upwards, but a hernia will not descend so long as the pressure is maintained.

*From varicocele**(c) Inguinal Hernia in the Female*

This is not nearly so common as in the male and is very rare in children. It is always of the oblique variety and may reach the labium, distending it far beyond its normal size. The round ligament is usually closely

incorporated with the sac but may sometimes be separate from it. The contents are usually omentum and small intestine, but sometimes the tube and ovary and very rarely the fundus of the uterus may be present. Occasionally the sac is obliterated near the neck and the distal part is dilated with fluid, forming a cystic swelling known as hydrocele of the canal of Nuck.

(d) Operative Treatment of Inguinal Hernia

In infants This may conveniently be considered in relation to the age periods. In infants up to two years a truss is often advised in the hope that if the sac is kept empty a cure will result, but the method cannot be recommended (see p. 478). On the other hand operative treatment is most satisfactory but should not be carried out until the child is thriving normally. About three months is usually a suitable age.

Operation The operation should be performed under general anaesthesia. It is only necessary to cut down on the inguinal canal, to define and isolate the sac, and to ligature it off as high up as possible. If the sac is of the congenital variety it must also be divided just above the testicle. The lower part, which forms the tunica vaginalis, should be left open, because its closure by suture or ligature encourages the formation of hydrocele. In these young infants the constituents of the cord are spread out over the sac, and great care must be taken not to divide or tear the vas. If this accident occurs, the ends must be approximated by a fine catgut suture, which if possible should be passed through the lumen of both ends. After the complete and high removal of the sac one or two sutures may be used to draw together the pillars of the external ring, although it is doubtful if this is essential.

As soon as the incision is soundly healed the child may leave his bed and, a day or two later, begin to walk. No irksome after-treatment is necessary.

In children In children between 2 and 16 years of age the external oblique muscle should be divided over the whole length of the canal, because this allows of more thorough and complete removal of the sac. Two or three sutures of No. 1 chromic catgut may then be used to stitch the internal oblique muscle and conjoint tendon to the inguinal ligament superficial to the cord (i.e. without displacement of the cord). The external oblique muscle is then carefully repaired and, if sufficiently lax, is overlapped. At the end of two weeks the child may be allowed to be up and two weeks later may resume his ordinary life.

In adults After the age of 16 years the patient should, like an adult, be treated by the complete Bassini operation, which has given a larger measure of success than any other operation for hernia. The steps are as follows:

Bassini operation

(1) Exposure of the whole canal by an adequate incision through skin and subcutaneous tissues. (2) Division of the external oblique muscle in the direction of its fibres from the external ring to a point well above the level of the internal ring. (3) Identification and opening of the sac with

treatment of the contents. (4) Separation and isolation of the sac to the highest possible point, which ought to be well above its neck. (5) Ligature and removal of the sac. (6) The formation or reconstruction of the posterior wall of the canal by suture of the lower edge of the internal oblique muscle and transversalis muscle and conjoined tendon to the inguinal ligament behind the cord. (7) Repair of the external oblique muscle, the margins being overlapped if the structure is at all lax. (8) Careful suture of the skin, and dressing with support of a bandage for at least forty-eight hours, after which the dressing may be fixed with collodion or strapping. Chromic gut is the best suture material.

If the wound heals satisfactorily young healthy adults may be allowed to get up and about, carefully, in a fortnight, but older patients should remain in bed for three weeks. Light work may be resumed in five or six weeks from the operation but very heavy work not before three months have elapsed.

After-care

During the operation great care must be taken not to injure the femoral vessels. This accident can always be avoided by passing the needle through the inguinal (Poupart's) ligament *from its deep surface*, the ligament being thus lifted from the vessels before being actually pierced by the needle. Care must also be taken not to injure the bladder (see also p. 502).

Complications and sequelae

Injury to femoral vessels

Among local sequelae the commonest is haematoma of the cord. This may become apparent about ten days after the operation. The swelling, which may be considerable, is at first diffuse but gradually becomes localized as a firm rounded lump. It nearly always readily undergoes absorption, without affecting the after-result. Suppuration is very rare. The importance of haematoma is the mental disturbance which may occur if the patient discovers the lump and assumes that the operation has failed.

Haematoma

Hydrocele and atrophy of the testicle, now rare sequelae, were probably due to removal of the veins of the cord when that practice was usual.

Hydrocele and atrophy of testicle

Operation in the female

In principle the operation in the female is the same as in the male; but, as there is no spermatic cord to consider, the canal may be completely closed after removal of the sac. Whenever possible the round ligament should be separated from the sac and left in situ. If this structure is closely incorporated with the sac it may be removed with it, apparently without detriment.

When the sac descends far into the vulva its separation may involve considerable bleeding from the vascular tissues of the labium, and a troublesome haematoma may result. In these circumstances the sac may be cut across as it enters the vulva, the upper part being separated and ligatured off. The fundus may then, after the plan associated with the name of A. E. Barker, be left in situ, a satisfactory procedure which simplifies the operation materially. If this method is adopted the mouth of the portion left behind must not be closed.

Treatment when sac descends into vulva

*Direct inguinal hernia**Keynes's
method*

In this variety the difficulty is to close satisfactorily the aperture through which the hernia leaves the abdomen. Occasionally the conjoined tendon can readily be brought down to the inguinal ligament, but often this cannot be done or can only be done with too much tension. In these circumstances the remaining gap should be closed by fascial suture. Another method (Geoffrey Keynes) is to turn down and suture to the inner part of the inguinal ligament a flap cut from the sheath of the rectus muscle. This may be reinforced by bringing down the muscle itself—a simple procedure when the muscle is freed from its sheath. If the hernia is unusually large or the muscles very poorly developed, both courses may have to be adopted. But each case must be dealt with as the indications demand.

(2)—Sliding Hernia

675.] In this type an extraperitoneal part of the intestine herniates in relation to a sac that covers only perhaps a third of its circumference. The bare area of the intestine is always the postero-lateral aspect. The bowel involved is either the caecum and some part of the ileum on the right side or the sigmoid on the left. True sliding hernia is always of the oblique variety and represents less than 5 per cent of all herniae. The condition is commonest on the right side and is usually associated with a large and relaxed abdominal ring. Strangulation is rare.

Treatment

Treatment is most unsatisfactory, for many of the cases relapse. The operation is conducted on ordinary lines, because the condition is seldom diagnosed before interference. The mouth of the sac must be closed by suture, the whole being readily returned to the abdomen; but it is very difficult to ensure its retention. Probably an intra-abdominal fixation of the bowel should be combined with the hernia operation.

(3)—Hernia with Undescended Testicle

676.] The treatment of this combination is concerned more with the testicle than with the hernia (see TESTIS, UNDESCENDED). When treatment of the testicle is deferred to a later age, the hernia, if causing trouble, may be dealt with on the lines described above. As the patients are young children, it is sufficient to separate and remove the sac, correcting the position of the testicle by endocrine therapy or, at an appropriate age (usually between twelve and fourteen years), by operation. When, on the other hand, the herniotomy is performed later in life, it may be combined with an attempt to secure the testicle in the scrotum. If this is impracticable, the organ may be returned to the peritoneal cavity or the extraperitoneal tissue, the radical cure of the hernia being conducted as already described. In yet other cases castration may be combined with the cure of the hernia. In such cases the canal should be completely closed.

*Treatment in
children**In adults**Combination
with
castration*

(4)—Interstitial Hernia

677.] This condition, which always occurs in the inguinal region and in which the sac or some part of it is situated between the muscles of the abdominal wall, is often associated with imperfect migration of the testicle but may occur independently. When recognized it is not difficult to deal with. The sac can usually be readily enucleated and removed, the other steps of the radical cure being then carried out in the ordinary way.

(5)—Femoral Hernia

678.] This form of hernia occurs in both sexes but more often in females in the proportion of 3 to 1. It is commoner on the right side but is often bilateral. Though much more frequent in adults, it may occur in children and especially in girls about fourteen. It is almost unknown in infancy. *Incidence*

The hernia presents on the inner side of the femoral vessels just below the inguinal ligament and below and external to the pubic spine. The sac leaves the abdomen by way of the femoral canal just to the inner side of the vessels. In this situation it forms a smooth rounded swelling usually about the size of a walnut, though occasionally it may be as big as a tangerine orange. Very rarely the hernia may be so large that it occupies the width of the limb; the sac may then form a pendulous swelling, or it may pass upwards towards the anterior superior spine and even overlap the inguinal ligament. Even when the hernia is reducible the empty sac is often thick and forms a swelling which may be visible and readily palpable. The sac usually contains some fluid which helps to give it a characteristic rounded soft feeling. The usual content is small intestine and omentum, and sometimes, on the right side, part of the caecum. Occasionally the end of the uterine (Fallopian) tube, or the tube and ovary, may occupy the sac. These herniae are often irreducible as regards some part of their contents and are much more liable to strangulation than is the inguinal variety. *Size of swelling*

Varix of the internal saphenous vein, an enlarged lymphatic gland, a psoas abscess bulging in the femoral region, and lipoma are the only conditions likely to give rise to confusion. *Differential diagnosis*

Varix is usually but not always associated with varicosity of the whole internal saphenous vein. The impulse on coughing has the character of a fluid thrill rather than an expansile bulge, and the whole lump immediately disappears when the patient is recumbent. *From varix*

An enlarged gland is usually oval in shape and more superficial; there are usually other enlarged glands for which some cause can be discovered, and unless they are inflamed the fingers can be introduced behind the swelling. If there is any question of strangulation, difficulties of diagnosis must be cleared up by surgical exploration, which is much safer than waiting. *From enlarged lymphatic gland*

Psoas abscess presenting in this region is usually external to the vessels and is always associated with a swelling in the iliac fossa, pressure on *From psoas abscess*

which produces a thrill of fluctuation which can be felt in the femoral swelling. In addition there will be the signs of the causal lesion in the spine.

From lipoma Subcutaneous lipoma has its characteristic features, but there may be a lipoma of the hernial sac which is confusing.

Treatment If the hernia is completely reducible, it can usually be easily controlled by a properly fitting truss. None the less, because of the risk of strangulation, operation is the wisest course, unless there is some very obvious contra-indication.

Operation by lower route

Operation Of the two operations, that by the lower route is quite satisfactory for
Incision moderate-sized ruptures. The incision is made parallel to and about an inch below the inguinal ligament, which will usually place it over the summit of the swelling. It should be three or more inches long, the exact length being determined by the size of the hernia. Division of the subcutaneous fat exposes the sac, which can then be very readily isolated by blunt dissection with the finger. Before opening the sac the inguinal ligament above, the fascia over the pectineus muscle internally, and the femoral sheath externally must each be identified. The sac should then be opened and the contents completely reduced into the peritoneal cavity. The empty sac may now be used as a tractor which is pulled upon while its neck is thoroughly exposed. During this stage traction should be kept up so that the peritoneum beyond, i.e. above the neck, is isolated.

Suture A suture of No. 1 chromic catgut is then passed through the highest part of the sac and is made to encircle each half, being then securely tied to ligature the sac off. The sac is cut away about $\frac{1}{8}$ inch beyond the ligature, and, if the stump is fatty and bulky, a stitch is passed across it and firmly tied to guard against its retraction from the grasp of the ligature. When the ligatures are cut, the stump is released from traction and should slip up into the extraperitoneal tissues of the pelvis. If this does not occur, the stump must be gently pushed into position through the femoral canal. The canal should now be free from fat and present a gaping aperture, which should be closed by a couple of sutures of No. 1 chromic catgut passed in front through the inner end of the inguinal ligament and behind through the pectineal (Cooper's) ligament, the strong fibrous structure which is closely attached to the pectineal eminence and may be looked upon either as the upper thickened edge of the fascia covering that muscle or as the attachment of the lacunar (Gimbernat's) ligament reflected along the pectineal eminence. Whatever its origin it is closely blended with the periosteum and is a very strong ligamentous band. These sutures should be tied sufficiently firmly to approximate the two structures in their grasp but not so tightly as to risk cutting through them.

One or two sutures should be used to draw the deep fascia together and should grasp the pectineus fascia in order to obliterate the dead

space just below the now empty femoral canal. Closure of the incision is now all that is required. The skin edges come together very well, and the incision lends itself admirably to the buried subcuticular stitch.

The upper operation (method of Parry or Lothiessen)

The femoral canal is approached from above the inguinal ligament by the inguinal route. The skin incision is the same as that used for inguinal hernia and extends over the whole length of the canal. The spermatic cord or the round ligament, as the case may be, is displaced upwards, and the peritoneum is bluntly separated in the same direction until the neck of the femoral sac is exposed. Similarly by blunt dissection the sac is isolated from its connexions and drawn up into the incision. When it is bulky this may be difficult or impossible, and it is then necessary to incise the sac and to deal with the contents. After these have been reduced, the sac can usually be withdrawn by steady traction, until the peritoneal funnel just above its neck can be exposed and isolated. The occluding ligature must be applied to this portion and the sac cut away. Some operators displace the stump of the sac by fixing it to the deep surface of the abdominal muscles above and external to its origin. The entrance to the femoral canal is now shut off either by stitching the inguinal ligament or the conjoined tendon to the pectineal ligament; when the canal is unusually patent both expedients may be used. Usually three or four interrupted sutures of chromic catgut will suffice. The external oblique muscle is then repaired, the edges being overlapped if it is sufficiently lax. The skin incision must be carefully closed, because good apposition will support the sutured external oblique muscle. If there is great difficulty in isolating the sac from above, a separate incision may have to be made below the inguinal ligament to facilitate this important step of the operation.

Incision

*Dissection
of sac*

The patient should be kept in bed for three weeks, or rather longer if the hernia has been very large or the tissues in a poor state of nutrition.

After-care

The only unpleasant sequel of either of these operations is swelling of the thigh. This is usually attributed to compression of the femoral vein as a result of a too tight closure of the canal, but it is much more likely to be due to phlebitis set up by a mild infection.

Sequelae

The mid-line extraperitoneal approach for femoral and inguinal hernia

The admirable exposure of the pelvic aspect of the femoral canal obtained by stripping the peritoneum from the pelvic wall in order to expose the lower ureter was observed by A. K. Henry, who accordingly uses this approach in the treatment of reducible femoral and inguinal herniae.

An incision is made in the mid-line from the umbilicus to the pubes without opening the peritoneal cavity. After exposure of the neck of the sac from above it can usually be enucleated from either canal by blunt dissection. In inguinal hernia an assistant must draw down the testicle from outside, because the separation is greatly facilitated when the structures are taut. After it has been withdrawn up into the extraperitoneal

area, the sac can be defined to a point well above its neck and can be ligatured off and removed.

It is suggested that by this method the funnel shaped process above the neck can be more thoroughly exposed. It is also regarded as especially useful for bilateral cases (see Fig. 74).

(6)—Hernia at the Umbilicus

*Incidence of
all types*

679.] Umbilical hernia usually occurs at two periods, namely, early infancy or middle age.

A child may be born with a gross defect of the abdominal wall involving the umbilical region (exomphalos). In other cases the site of

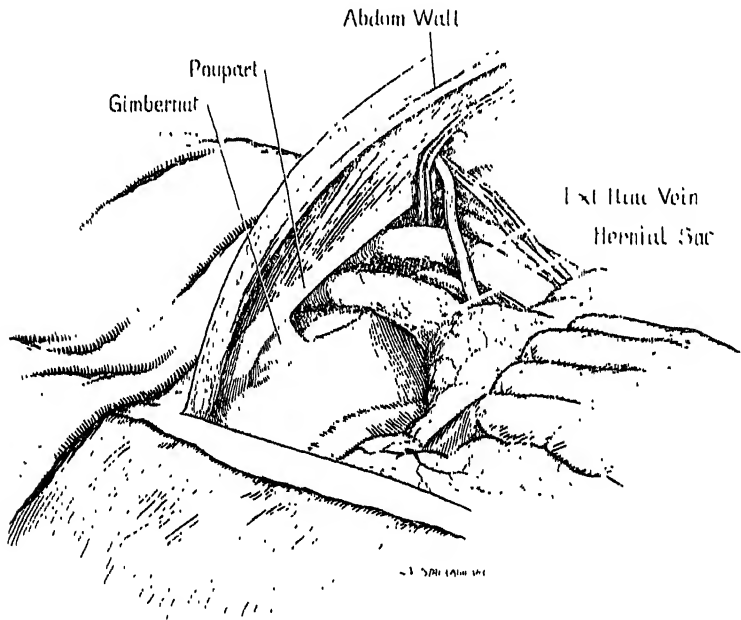


FIG. 74.- Extraperitoneal operation for hernia. Right femoral sac seen from left side, after separating the recti, when the hand has displaced the peritoneum from the pelvic wall. (*Lancet*, 1936)

the umbilicus cicatrizes normally but is occupied by a hernial protrusion; this is the infantile variety. Sometimes the hernia does not appear until the child is a few months old. The navel hernia of adults usually occurs in females about 35 to 40 years of age.

(a) *Exomphalos*

This condition is associated with failure of the intestines to withdraw into the abdominal cavity. At birth the cord is attached to the summit of a large thin-walled sac, and there is often persistence of some part of the omphalo-mesenteric duct. In such cases the persistent remnant may be inadvertently tied with the cord, with the result that an intestinal

fistula develops. The whole area is covered by the remains of the thin transparent amniotic membrane, through which the small intestine is visible (see Fig. 75). These patients often have other congenital defects and die soon after birth, but survivals are on record.

From the outset the area should be dressed with weak spirit, which hardens the covering membrane and renders it less likely to give way and so expose the abdominal contents. If general shrivelling and contraction of the sac do not quickly take place, operative interference is

Treatment



FIG. 75.—Exomphalos with bilateral inguinal herniae in an infant aged 8 weeks
(*Proceedings of the Royal Society of Medicine*, 1937)

indicated. The sac must be cut away and the contents returned to the abdomen, after which the walls are drawn together by sutures. There is often very considerable tension, and the parts must be carefully supported by strapping applied over the dressing.

(b) *Infantile Type*

It is generally assumed that in the infantile type spontaneous cure occurs or can easily be brought about by pressure. Cure does indeed occur often, but usually those responsible are satisfied merely by some degree of improvement, doing nothing more for what is regarded as an unimportant blemish. In many cases the sac persists unobtrusively until adult life, when unusual stress, commonly associated with child-bearing, leads to the development of the typical adult type of umbilical hernia. The condition in infants should therefore be regarded not from

the point of view of its comparative harmlessness but from that of its potentialities.

Two matters are important in the management of the condition in infancy: first, all causes of abnormal abdominal distension should be discovered and dealt with, and secondly, crying should be reduced to the minimum.

Pressure

Pressure over the protuberance is undoubtedly helpful, but it must be properly applied and continuous. A small flat pad made by wrapping a coin in lint does admirably. It must be firmly fixed over the site of the hernia by strapping and kept in position for three to six months. If this does not result in obvious cure, or if the condition recurs, or if the child is not seen until 1 or 2 years of age, operation should be advised. This consists in the removal of the sac with reconstruction of the abdominal wall by careful suture. The incision should be carried along the side of the umbilical cicatrix and reflected off the sac so that

Operation

it can be laid back into position at the conclusion of the operation. Removal of the cicatrix should be avoided, for it may make the child sensitive about its appearance and subject it to the ridicule of its school companions.



FIG. 76. —Large umbilical hernia

Incidence

appears about the age of thirty-five, is prone to increase in size steadily and may become enormous (see Fig. 76), containing in some cases a large part of the abdominal contents. It may occur in all kinds of persons but is commonest in obese women who have borne several children.

Examination of patient

In such patients a hernia as large as a closed fist may be hidden in the subcutaneous fat with only a very slight external protuberance. The examination must therefore always be conducted not only in the recumbent but also in the erect posture, in which the condition is always most obvious. As a rule fully developed herniae cannot be completely reduced.

Symptoms

The main complaint is usually of the inconvenience of the size and often of the weight of the protuberance. There may also be dragging pain, often referred to the back or to the neck and shoulders, and attacks of colic usually described as 'windy spasms'. These spasms are caused by some obstruction, though not necessarily actual strangulation. The surface of a very large hernia is irregular as a result of the loculation, and the skin is apt to be thin and ulcerated in places. The deep sulcus below the hernia is invariably infected and offensive.

(c) In the Adult

The umbilical hernia of adults, which usually

The great risk is strangulation. When this occurs operative interference is imperative, and the mortality, even in the more favourable cases, may reach 30 or 40 per cent; whereas with proper precautions the operation for radical cure has a mortality of about 2 per cent. In one series under my care there was one death in 103 cases of the radical cure in contrast with thirteen deaths in thirty-six cases operated upon for strangulation. Operation should therefore always be recommended during a quiescent period when time and care can be expended in preparation.

Most of the patients, being obese and heavy, are perforce indolent and in consequence often suffer from respiratory difficulty, chronic cough, and glycosuria. Their condition can often be greatly improved by regulation of diet, exercise, attention to the bowels, and measures directed to the respiratory and cardiovascular systems. For some time before the operation the patients should be put to bed, not only to help to diminish the size and tension of the hernia but in order that they may get used to a position which they might otherwise find intolerably irksome. During this time they should be made accustomed to the passage of the stomach tube, which may be required in the after-treatment.

The operation may be carried out under spinal or often under local anaesthesia, or under either of these in combination with a minimal quantity of inhalation anaesthesia.

The principles of the operation are those already laid down, special attention being paid to the matters discussed on page 486. After the contents of the sac have been dealt with and the sac has been removed, an attempt must be made to repair the defect in the abdominal wall. Fortunately even in the largest herniae the opening in the parietes is seldom larger than will admit three fingers. When the abdomen is neither very full nor tense, this aperture may often be successfully closed by overlapping its margins in a transverse direction (the Mayo method). Sometimes the defect can be more readily closed in the vertical direction, the structures being drawn together edge to edge as in the repair of a laparotomy; or they may be inverted to the extent of half an inch or more on each side, approximation being secured by mattress sutures. Sometimes none of these methods can be employed without great tension, or it may even be impossible to get the edges into apposition by any method. The sutures of thick No. 5 chromic catgut may then be supported by fascial strands, or the aperture may be 'darned' by a series of such strands after one of the methods of Gallie (see p. 481).

Whatever method is used, the after-care is most important (see also p. 489). If the wound heals satisfactorily, a rest in bed for about three weeks should be sufficient, but the patient should have the support of a flat strong elastic webbing bandage without any pad. This should be worn for about six months.

Naturally the prognosis as to freedom from recurrence is not nearly

Chances of recurrence

so good as in the other forms of hernia. Probably 25 to 30 per cent of the very large herniae recur to some extent, but even so the operation usually gives great relief, and any recurrence can be supported and controlled by some form of elastic belt.

Palliative treatment by belts

When operation is not considered advisable or is refused, the question of some form of external support must arise. When the hernia is not reducible, belts are of little avail, but a broad flat elastic band will exercise a general support and help somewhat to guard against increase in size. The enormous herniae cannot be controlled in this way; they may be supported or carried in a strong bag, which must be not only fixed by a band around the body but also supported by broad straps passing over the shoulders like braces. In the early completely reducible cases in patients who are not very fat a well fitting belt with a circular flat pad may keep the hernia reduced and add materially to personal comfort.

(7)—Incisional, Post-Operative, or Scar Hernia*(a) Clinical Aspects of all Types**Causes*

680.] This hernia may occur after any form of incision through the abdominal wall, whether the peritoneal cavity has been opened or not. It may also follow accidental wounds, especially those that are lacerated or irregular. Among the factors in its production are imperfect apposition or retraction of the edges of incisions or wounds; infection, especially if followed by suppuration; healing by granulation; bursting open of wounds; the too early removal of sutures; closure by single-layer suture; cough; and post-operative distension.

General features

The sac is seldom well localized and defined but takes the form of a diffuse bulging, extending along the whole line of incision and usually beyond the area at which the external swelling is obvious. Outlying loculi either above or below the maximum part of the bulging are also common. There are usually extensive and diffuse adhesions, with the result that the contents are matted together and uniformly adherent to the sac. Large areas of bowel wall are commonly involved, making it difficult to find any non-adherent area at which the sac may be opened. The edges of the defect in the parietes are apt to be widely separated by even as much as a hand's breadth, so that the sac is covered merely by stretched skin and attenuated scar tissue.

Symptoms

The symptoms are identical with those of umbilical hernia (see p. 496).

Prevention

Preventive measures include the careful placing of abdominal incisions, the avoidance of injury to nerves, and careful closure of the peritoneum by continuous suture to ensure that no portion of the omentum will escape between the edges and become imprisoned in the depth of the wound. Such pieces of omentum are prone to increase in size and drag on the peritoneum, thus forming a pocket which may develop into a hernial sac. In addition to layer suture a series of through and through

silkworm sutures which embrace all the layers except the peritoneum should generally be introduced. The whole wound should also be carefully supported during the immediate post-operative period. For this purpose large strips of wide elastic sticking-plaster should be used over the dressing, and a many-tailed bandage should be worn during the first forty-eight hours. At a later stage an elastic bandage is useful, especially when there is cough. Measures must also be taken to prevent and to relieve distension (see p. 502).

Treatment

In the management of these cases much of what has been said of umbilical hernia and of the very large herniae applies. Most cases demand operation.

Operation

In all cases it is essential to use adequate incisions exposing the whole of the old scar and excising stretched and cicatricial tissue. The margins of the defect are best defined before the sac is dealt with. If the latter turns out to be localized and is of reasonable size, it may be treated in the same way as umbilical hernia (see p. 497). On the other hand, if it is diffuse it may be a very serious matter to open it and attempt to separate all the adhesions. If obstructive attacks have been prominent this task is necessary, whatever its magnitude. In other circumstances the sac may be isolated from the edges of the defect in the abdominal wall and inverted as a whole without being opened, the margins of the defect being closed over the inverted area. The ideal is to repair the abdominal wall in layers as in a primary laparotomy; but before this can be attempted the scar tissue must be freely cut away until the normal structures are exposed. When the margins are very widely separated it is better not to attempt to define the separate layers but to unite the strong conjoined structure which forms the margin of the aperture.

Closure of wound

The methods of closure are those described in the section on umbilical hernia (see p. 497). Whenever possible, the procedure of overlapping the anterior sheath of the rectus muscle or the external oblique muscle should be carried out.

(b) Special Types

Although most of what has been said applies to all forms of incisional hernia, some further points about herniae in special areas should be mentioned.

Herniae after operations for appendicitis, caecostomy, or incisions over the sigmoid colon

These may be either localized at one part of the wound or generalized over the whole area. Even in the presence of a localized swelling the remainder of the scar is apt to be imperfect, and the whole area should therefore be exposed and examined. The external oblique muscle is usually widely retracted, and the deeper muscles, although not so extensively retracted, are usually much scarred.

After proper exposure beyond the confines of the original incision

Treatment

the sac may be dealt with. If the appendix has not previously been removed or there is doubt about this matter, it must be found and ablated. In these cases it is usually possible to get the deep muscles together without tension and to support them by overlapping the external oblique muscle.

Herniae following oblique or transverse muscle cutting incisions for gall-stones or for exposure of the kidney

These are very difficult to deal with because although the edges of the retracted muscles can be readily exposed, they cannot be united without great tension, and the sutures are very prone to cut through. In these circumstances the use of Callie's method becomes imperative (see p. 481).

In the immediate after care the patient should be nursed in the position which provides the maximal amount of relaxation to the involved area.

Suprapubic hernia

Suprapubic hernia may follow drainage of the pelvis by this route or operations on the bladder. These herniae are often very difficult to support by any form of apparatus, and operative treatment is often desirable. The sac can usually be well defined and often inverted without being opened. Great care must be taken not to injure the bladder, which is often drawn into the sac. It may be difficult or impossible to get the edges of the parietal defect together. The use of fascial sutures provides one solution; another is to transplant the recti muscles. The lower two or three inches of these muscles must be separated from their sheaths and then completely divided about an inch above their insertions into the pubes. The muscles are then crossed over the defect, each being sutured to its fellow. The anterior sheath is then carefully and independently repaired. This comparatively new method is said to have yielded good results (Nuttall).

*Closure of
aperture*

Sacral hernia

Sacral hernia occasionally follows excision of the rectum when there has been free removal of bone. Beyond the alarm occasioned by the presence of the unexpected protrusion and a mild sense of weakness it does not cause troublesome symptoms.

It is not amenable to surgical intervention, but some support may be provided by a pelvic belt with a pad over the hernia kept in position by means of a perineal strap.

6.—THE PROBLEM OF VERY LARGE HERNIAE

681.] As a rule these are either inguinal (see Fig. 77) or umbilical; fortunately, large incisional herniae are not common. In any case their management may present great difficulties. The patients usually complain

of the size, weight, and appearance of the encumbrance rather than of any pain. They often suffer from severe constipation and are liable to attacks of obstruction or sometimes of strangulation. In the absence of any complicating factor it is often very difficult to decide whether or not to advise operation, and account must be taken of the patient's general health as well as of the local condition.

Indications and contra-indications for operation

Cough for which a cause cannot be assigned and which cannot be controlled by suitable remedies is undoubtedly a contra-indication to operation, except when the latter is a life-saving measure. Patients with large herniae are often obese and not uncommonly suffer from glycosuria. If this can readily be controlled, either by dietetic measures or by these together with the proper use of insulin, it need not be an absolute obstacle to surgical interference, although it heightens the risk. The state of the cardiovascular system also has a definite bearing on the matter.

Cough

Glycosuria

Among the local conditions, the size of the hernia must be considered in relation to the build and the capacity of the abdomen. If with a large hernia the abdomen is already distended and tense, it is often mechanically impossible to add the contents of the hernia to those of the abdomen without seriously embarrassing diaphragmatic

movements and causing great distress to the patient. If, on the other hand, the abdomen is lax and gives the impression of emptiness, then the addition of the hernial contents will probably not unduly tax its capacity. If there is any doubt an attempt should be made to reduce the hernia in order to observe the condition of the patient when this has been brought about. Often such reduction cannot be accomplished by manipulation, but, if the patient is put to bed and kept on the back with the pelvis and legs higher than the head, the contents of the hernia will in many cases slide or be dragged into the abdominal cavity by the aid of gravity. If, when this occurs, the patient is reasonably comfortable, it may be assumed that the hernia can be repaired with advantage. Even in cases with complications, such as obstruction or strangulation, these considerations bear on the management of the case. If, for instance, it seems impossible for the abdomen to contain the hernia, then the surgeon must be content to open the sac,



Size of hernia

FIG. 77.—Large left inguinal hernia with hydrocele on right side

deal with the obstruction or the strangulating agent, and merely repair the sac without attempting either to reduce the contents into the abdomen or to carry out radical cure.

*Preparation
of patient*

If an operation is contemplated on one of these enormous herniae, some little time should be spent in preparation. Superfluous fat can often be reduced by suitable diet assisted by purgation. At the same time treatment may be directed to the cardiovascular and pulmonary systems. The patients often find it very trying to lie in bed in some one fixed position and should therefore be accustomed to the ordeal by a period in bed before the operation. During this time it is wise to get them accustomed to the use of the stomach tube, for this is often required in the after-treatment.

Anaesthesia

Inhalation anaesthesia should be avoided and spinal or local infiltration used whenever possible. Arrangements for general anaesthesia should be in readiness, however, because the patients are often of a build in which difficulties occur in producing spinal anaesthesia and the hernia may be too large for satisfactory local anaesthesia.

Incision

In planning the incisions it is important to be guided by the appropriate anatomical landmarks, which often are obscured by the size of the parts and the wide separation of the structures concerned.

The essentials for the radical cure are the same as in all herniae and include thorough isolation and removal of the sac together with approximation of the margins of the opening. For the latter the methods adopted may be those mentioned on page 497; or, if the margins cannot be made to meet, the opening may be partially closed and the remainder covered by a lattice work of fascial strips. The use of silver filigree has many disadvantages and is now very rare.

After-cure

Distension must be avoided by every means e.g. the regulation of diet, the passage of the stomach tube, the use of the rectal tube, and stimulation of intestinal action by pituitary (posterior lobe) extract, small doses of strychnine at frequent intervals, and small divided doses of calomel. Accumulation of bronchial secretion should be avoided by encouraging the patient to cough, the area of operation being manually supported meanwhile. As in all cases of abdominal operation in stout people the bladder must be watched. Such patients often pass urine unaided, but they do not always empty the bladder, and the gradual accumulation of residual urine may have serious results. Any doubt must be settled by use of the catheter.

7.—HERNIA OF THE BLADDER

682.] There are very few cases in which the bladder is the sole content of a hernial sac, and it would be more proper to speak of the relation of the bladder to hernia than of hernia of that viscus. Some part of the fundus of the bladder may be free in a hernial sac, or it may be partially free in the sac and partially extraperitoneal, or it may be entirely extra-

Types

peritoneal. These conditions are conveniently described as intra-peritoneal, paraperitoneal (see Fig. 78), and extraperitoneal.

The association of the bladder with a hernial sac is most common in direct inguinal hernia; it occurs less often in the indirect variety, and least of all in femoral hernia. It is far more usual in adults than in children. As a rule the condition is not suspected before operation, and the bladder is accidentally discovered when the neck of the sac is being isolated, coming into view on its inner side. It is identified by the surrounding fat, the large veins, and the characteristic muscular fibres. When it is recognized, the separation must not be pursued further, because the bladder wall is easily torn, often with fatal results. Should a tear occur or should the bladder wall be so thinned that it appears likely to give way, the involved area should be turned in by a couple of superimposed purse-string sutures. It is wise to place a very small strand of rubber tissue or a tiny tube in contact with the invaginated area to act as a drain in case of leakage. The operation for the radical cure is then proceeded with as usual.

Occasionally a portion of the bladder has been included in the ligature of the sac and a secondary leak has followed, sometimes with fatal consequences. On other occasions the ligature used for the sac has perforated the bladder, and haematuria has resulted. Sometimes such a ligature has found its way into the bladder and has formed the nucleus of a calculus.

When part of the bladder is the sole content of the sac, the patient may complain of urinary symptoms such as dysuria and frequency; there may be urination in stages, the patient perhaps discovering that pressure on the hernia enables the act to be completed. If in the inguinal canal there is a swelling which always goes down after urination, or if to get complete relief from this act the patient has to manipulate such a swelling, the diagnosis of hernia of the bladder is irresistible. In these circumstances some part of the fundus of the bladder or a diverticulum probably forms the sole content of the sac. (See also Vol. II, p. 400.)

Strangulated hernia of the bladder has been described.

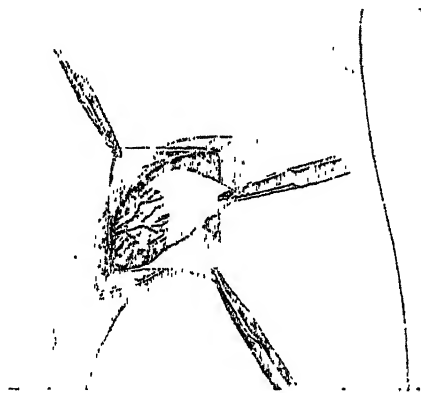


FIG. 78.—Drawing reconstructed from sketch made at operation. Well marked paraperitoneal hernia of bladder adherent to peritoneal sac. Dilated veins and fat lobules seen on surface of bladder. (*British Journal of Urology*, 1930)

Inclusion of bladder in ligature

Strangulation

8.—HERNIA AND THE VERMIFORM APPENDIX

683.] *Appendix in hernial sac*

The vermiform appendix may be found in inguinal and femoral herniae on either side of the body, or in the sac of an umbilical hernia. It may be the sole occupant of the inguinal and femoral hernia or be accompanied by the caecum; or it may share the sac with small intestine or with omentum. In other cases it may lie just at the mouth of a hernial sac, into which the products of any inflammation would thus naturally find their way.

The relations of the vermiform appendix to hernia may be expressed as follows: (i) it may be free in the sac without signs of disease; (ii) it may be strangulated alone or with other viscera; or (iii) it may be inflamed, perforated, or the cause of an abscess in the sac. Another possibility is that the products of a neighbouring appendicitis may find their way into a preformed sac.

*Indications
for
appendic-
ectomy*

When in a hernial sac with other structures, the appendix need not be removed unless the conditions are such that this step will not materially add to the risk of the operation. When strangulated in inguinal or femoral hernia it should be removed; in such cases the base of the organ must be fully exposed so that it can be safely excised and its stump buried. As a rule the caecum can be drawn into the sac after relief from the strangulating agent, but, if it cannot be safely exposed, it is better to deal with the appendix through an independent incision over the iliac fossa (i.e. as an addition to the hernial exposure).

*Appendicitis
in hernial sac*

True appendicitis without strangulation is rare in a hernial sac and is one of the causes of 'inflamed hernia'. The disclosure usually comes as a surprise when the surgeon has to deal with what appears to be an anomalous type of strangulation. In these circumstances part of the base of the appendix is also in the sac and thus renders removal of the inflamed organ comparatively simple. Sometimes this may be safely followed by removal of the sac, but, if the inflammation is extensive or the general condition of the patient bad, it is much better simply to pack the sac with gauze so as to shut it off from the peritoneum and to act as a drain, leaving the hernia to be dealt with subsequently. Sometimes the inflammatory process leads to safe obliteration of the sac.

In other cases the appendix is in an abscess in the sac; in such cases the abscess should be merely opened and drained, the appendix and the sac being left for removal as an interval operation.

More rarely still, suppuration in a hernial sac may be an extension from an appendicitis in the iliac fossa. In these circumstances it is wiser merely to drain the abscess and to deal with the causal condition in the ordinary manner (see APPENDICITIS, Vol. I, p. 736).

Inguinal hernia following operations for appendicitis

This is not uncommon and has occurred after every type of incision employed for removal of the appendix, though more commonly after

the oblique incision. The usual history is the development of an oblique inguinal hernia usually within twelve months after the appendix operation. The hernia occurs just as often when the appendix wound has healed satisfactorily as otherwise, and in the absence of any incisional hernia.

There are three suggested explanations: (i) that the condition follows some damage to the nervous supply of the muscles of the hernial region, which undergo local atrophy; (ii) that the rigidity of the abdominal wall about the abdominal scar throws some extra strain on the inguinal region; and (iii) that this strain is more likely to cause hernia if there happens to be a pre-existing sac. *Explanations of condition*

The treatment does not present any unusual problems. If the muscles guarding the canal are atrophied it is desirable to use fascial sutures for their repair. *Treatment*

9.—OTHER FORMS OF ABDOMINAL HERNIA

Epigastric hernia

684.] This hernia, known also as hernia of the linea alba and fatty hernia of the linea alba, is not uncommon, and is more usual in males and in spare subjects. It may be merely a protrusion of a small mass of extra-peritoneal fat—the fatty hernia of the linea alba—or there may be a definite sac communicating with the peritoneal cavity. Probably the sac results from the traction exerted by the steady growth of masses of fat which find their way through the mid-line. As a rule it is empty, but it may contain omentum, either great or lesser. Only very rarely does it harbour any portion of the viscera, and when that occurs it is usually a knuckle of the stomach. The commonest site is about midway between the ensiform and the umbilicus. The protuberance is quite small, like the end of a digit, but it may be flattened and perhaps 1½ inches in diameter. There is usually no gurgle and no impulse on coughing. *Incidence*

Patients may have accidentally discovered the lump, or may have experienced some local dragging, dyspeptic symptoms, or functional disturbance. Very rarely the contents of such a hernia may become strangulated. It is essential to be sure that the symptoms are really due to the hernia, for symptoms caused by malignant disease of the stomach, duodenal ulcer, or other conditions are sometimes attributed to these small external swellings. When the diagnosis is still in doubt, the condition may be treated by a firm pad of lint kept in position by a few strips of plaster. If investigation does not disclose some underlying condition and the symptoms are not relieved by the pressure, an operation should be carried out. *Symptoms*

A vertical incision should be made over the lump, which must be isolated from the surrounding tissues. The linea alba will probably have to be incised above and below the neck. The sac can then be opened *Operation*

and, after the contents have been dealt with, may be cut away. The abdominal wall is closed as in laparotomy.

Hernia through the linea semilunaris

This hernia, also known as lateral or Spiegel's hernia, is much rarer than the epigastric variety but is similar in most respects.

Obturator hernia

Unless it happens to cause strangulation this hernia is very rarely discovered. It is six times commoner in women than in men, and usually occurs in the aged who have recently lost flesh and have wide pelves. The sac leaves the pelvis with the obturator vessels and burrows between the pectineus and the adductor muscles on the inner aspect of the thigh. It is very exceptional to find an external swelling. The one characteristic sign is known as the Howship-Romberg syndrome—pain referred down the inner side of the thigh to the knee and made worse by abdominal distension and coughing but not by movement of the hip-joint. Sometimes a swelling has been felt on vaginal examination. Strangulation has been present in half the recorded cases.

*Howship-
Romberg
syndrome*

It is only very rarely that this form of hernia can be diagnosed with any assurance, but it should be suspected as a cause of intestinal obstruction in thin old women, especially if they have complained of pain down the inner side of the thigh. As a rule the hernia is only discovered on exploring the abdomen for acute intestinal obstruction. In many cases only a very small knuckle of intestine is involved, and a partial enterocele (Richter's hernia, see p. 507) is usually found.

Treatment

The intestine may readily be withdrawn into the abdomen, or it may first be necessary to incise the neck of the sac. When the intestine has been dealt with, it may be possible to pull the sac out of its bed towards the abdomen, i.e. to invert it into the abdominal cavity, after which a ligature may be applied to its neck, the redundant part being cut away.

If this cannot be done, it is nearly always possible to run a purse-string suture around the mouth of the sac or to draw the margins of the neck together, thus causing obliteration and guarding against recurrence. The mortality is very high owing to the late stage at which the diagnosis is usually made. In the very few instances in which the hernia is diagnosed before the occurrence of strangulation its repair demands an approach from within the abdominal cavity rather than from the obturator region of the thigh.

Lumbar hernia

Lumbar hernia usually follows some type of incision for exposure of the kidney; but it may arise spontaneously and present through the lumbar triangle (of Petit). It has occurred in children. As a rule there are few if any symptoms, and all the treatment required is support by a belt with a flat pad. If such an apparatus is not efficient, the hernia may be operated upon. As in all herniae, the sac must be removed and

Treatment

the opening through the abdominal wall closed. In some cases the defect must be repaired with fascial sutures used like a lattice work. Strangulation has occurred.

Sciatic hernia

This is so rare that it is of little practical importance.

Perineal hernia

Perineal hernia occurs through the pelvic floor and is also extremely rare. Lipomas or fibromas originating in the ischiorectal fossa may simulate hernia, for occasionally they present in the perineum and can be pushed back towards the fossa.

Littre's hernia

Littre's hernia is the term applied to a hernia in which Meckel's diverticulum is the sole occupant of the sac. It is very rare. When strangulation occurs the symptoms are anomalous, for obstruction is not necessarily present.

Richter's hernia

In this form part only of the circumference of the bowel is found in the sac, hence the synonym 'partial enterocele'. It usually comes under notice in cases of strangulation. As in the variety previously mentioned the symptoms may be anomalous.

*Partial
enterocele*

III.—DIAPHRAGMATIC HERNIA

685.] This variety of hernia, though not common, is less rare than is generally recognized. It consists of a protrusion of some abdominal viscus or viscera, in part or as a whole, and with or without a peritoneal sac, into the chest cavity. The cases can be conveniently classified as: (i) traumatic; and (ii) non-traumatic, either congenital or acquired.

Cases of the traumatic type result from severe crushes of the chest or from such injuries as stabs or gun-shot wounds. The defect is generally in the dome of the diaphragm.

Traumatic

The non-traumatic type can best be understood by reference to embryological factors. In the early development of the foetus the pleural and peritoneal cavities form one cavity, but during the third month of intra-uterine life the development of the diaphragm is completed by the muscularization of the septum transversum. This takes place in five portions of the septum; the muscular fibres grow through the membranous structures reaching the dorsal margins last of all. Want of complete development of any one portion, or failure of fusion between the various portions which go to complete the whole structure, may result in a defect through which the hernia occurs. The presence of the great bulk of the liver on the right side explains why the hernia is so

*Non-
traumatic*

much more common on the left. Probably many examples occur in the newly born in association with other defects not compatible with life, so that these infants do not survive the immediate post natal period. Those that survive may go through life without trouble, or they may show symptoms in childhood or adult life. A few cases are discovered during the course of examination when some other abnormal condition is suspected.

The usual sites of these congenital defects in order of frequency are: (i) the costo-vertebral region—persistence of the left pleuro-peritoneal hiatus; (ii) the oesophageal region when (*a*) the hiatus is not developed and is replaced by a large defect—the hernia transversa diaphragmatica, or (*b*) the hiatus is present but abnormally patent allowing the formation of a para-oesophageal or hiatus hernia; (iii) the posterior part of the left dome; and (iv) the retrosternal region.

Anatomical features

The size of the aperture varies greatly. In some congenital cases almost the whole muscle seems to be absent, the two cavities of the pleura and peritoneum apparently communicating freely with one another. More usually the orifice is not larger than will admit three fingers. The margins of the orifice may be rounded and muscular or sharp and fibrous. In most congenital cases there is a definite peritoneal sac, but this may be entirely absent, as it usually is in the traumatic varieties.

Contents of sac

The contents of the sac vary; as a rule they consist of some portion of the stomach and colon, and sometimes also of coils of the small intestine. The spleen may accompany the stomach. The contents may be quite free, or may be adherent diffusely or only at the margins. In the absence of a sac the viscera may be adherent to the lung and to the pericardium (see Fig. 79). The thoracic viscera are always displaced to some extent and, when the hernia is very large, the lung may be pushed to the apex of the pleural cavity and the pericardium thrust towards the opposite side.

Symptoms

The condition may exist throughout life without producing any symptoms, or there may be symptoms for a series of months or years, or no indication of anything amiss until strangulation occurs. When chronic symptoms have persisted for years, a sudden exaggeration may herald the onset of strangulation. In some cases the cause of otherwise unexplained intestinal obstruction may be a strangulated diaphragmatic hernia. The symptoms have often suggested gall-stones, which in many cases have complicated this form of hernia. Occasionally the gall-stones have been safely dealt with, but a continuance of symptoms has prompted a further and more detailed examination which has revealed the true cause.

The more usual symptoms have been referred to the stomach—indigestion, and pain associated with a sense of extreme distension aggravated by food and relieved by eructations or vomiting. Patients often say that they are afraid to eat.

Gastric lesions, especially ulcer or hour-glass contraction, are often present; shoulder-tip pain may be a feature. In some cases oeso-

phageal obstruction may closely simulate cardiospasm. Pain is sometimes so agonizing as to simulate true angina pectoris. Displacement of the heart causes tachycardia. When the colon is in the sac, there may be symptoms of chronic obstruction suggesting carcinoma of the colon.

In the large herniae ordinary examination may disclose signs suggesting that there is a hollow viscus in the chest, and these signs may be associated with retraction and a strange emptiness of the abdomen. In most cases diagnosis has only been made by careful X-ray investigation,

*Physical
signs and
diagnosis*

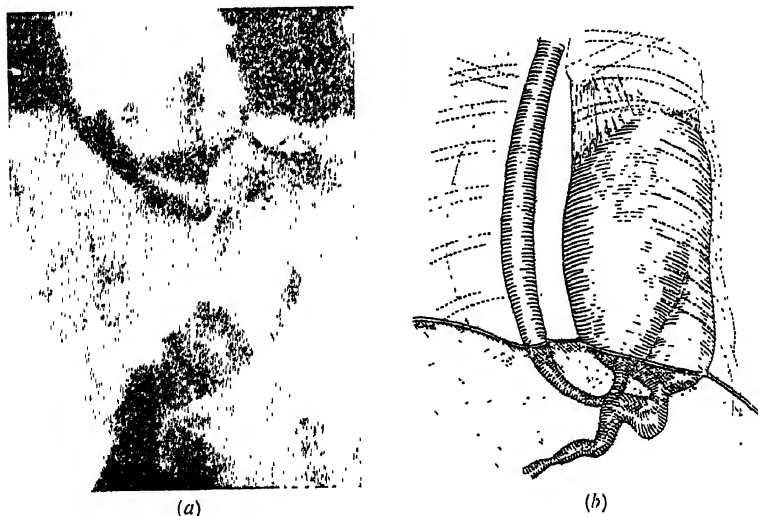


FIG. 79.—Diaphragmatic hernia of stomach. (a) Oesophagus enters stomach in the abdomen, the stomach at once enters the thorax. A narrow line of barium indicates its exit from the thorax, the pyloric portion of the stomach being in the abdomen. (b) This drawing is an exact reconstruction of another film, with the adhesions drawn in, and explains (a). It shows adhesions between stomach and compressed lung. (*British Journal of Surgery*, 1935)

which in order to be as efficient as possible should include films made not only from front to back but from side to side, and if necessary with the patient in a moderate degree of the Trendelenburg posture. Both opaque meals and opaque enemas may be necessary, and they may have to be used simultaneously. The screen examination will probably furnish more information than plain films. It may help to elucidate some cases if an opaque oesophageal bougie is passed during the examination. In no class of case is repeated examination more necessary and close co-operation between clinical and X-ray experts likely to be more fruitful.

In some cases with few or very slight symptoms it may be wise to leave well alone and to withhold interference. The knowledge of the presence of the condition may be most valuable if symptoms arise, especially if there is any question of acute obstruction. In the presence of definite

Management

symptoms it is advisable to interfere during the quiescent period and not to risk the onset of an emergency.

*Operation
Incision*

The question of the approach largely depends on the type and situation of the hernia and whether the contents are known to be reducible. In practice this usually means that the approach should first be made from the abdomen so that the under surface of the diaphragm may be carefully examined. A mid line epigastric incision is most useful, although some surgeons prefer an incision parallel to and just below the left costal margin. The reversed Trendelenburg posture is useful at this stage and further exposure may be obtained by separating the left lobe of the liver from its diaphragmatic attachment and drawing it towards

*Withdrawal
of contents*

the right side. If the aperture can be readily exposed the contents may easily be withdrawn into the abdomen. In some cases, however, this may be very difficult, partly owing to negative pressure or suction, which may be overcome by introducing a tube into the hernial sac by the side of the contents or by puncturing the pleura. Once the contents have been withdrawn an attempt must be made to close the aperture.

*Closure of
aperture*

The margins may be drawn together with stout catgut and the closure can often be reinforced by applying the mobilized left lobe of the liver to the sutured area. If the margins of the aperture cannot be drawn together, it may be entirely occluded by applying the liver to its under surface, or the space may have to be laced over with fascial strands. If the contents cannot be readily withdrawn through the abdominal incision, the chest must be freely opened and the sac exposed from above, so that adhesions may be dealt with under the guidance of the eye. It is often much less difficult to close the orifice from the chest surface of the diaphragm than from below.

*Treatment of
strangulation*

In strangulation the patients are often so ill that the least possible interference must suffice, and if the condition can be relieved by opening the abdomen and withdrawing the intestine from the hernia the question of radical cure may have to be left until another time. There is, however, a great risk of recurrence, and this further interference should not be too long delayed.

Sometimes the stomach is so much distended, and has been so long in the chest cavity, that there does not seem room for it in the abdomen. In these circumstances Dunhill has found it advantageous to perform a temporary gastrostomy. There is a considerable risk of collapse of the lung after these operations, and Harrington of the Mayo Clinic strongly advises that the patients should be nursed in an oxygen tent.

*Indications
for
conservative
treatment*

Finally it must be realized that surgical intervention is always serious and that there are many possibilities of disaster. Even in the presence of symptoms a conservative policy deserves serious consideration. The milder troubles may often be relieved by the treatment of associated lesions and perhaps by the occasional passage of the stomach tube. Phrenicotomy, by relieving diaphragmatic spasm, has given great relief and is a useful preliminary if surgical intervention is required.

If small intestine can be demonstrated in the hernia, operation is the

wisest course, for strangulation is very liable to occur and to prove fatal.

The final results of these operations should be judged more by the relief which the patients obtain than by the subsequent X-ray appearances.

For short oesophagus with thoracic stomach see OESOPHAGUS DISEASES. Diaphragmatic hernia is also discussed under the title DIAPHRAGM DISEASES, Vol. III, p. 677.

IV.—HERNIA CEREBRI

686.] Congenital hernia cerebri is described under the title FOETUS DISEASES, Vol. V, p. 370. The acquired condition may be classified in two groups as follows: (i) the protrusion of some portion of the exposed brain through a wound or incision which has become mildly infected; this is the 'fungus cerebri'; (ii) a localized bulging of the brain beyond the confines of the skull but covered by the intact scalp. This condition is common after operations for the exploration of intracranial tumours which cannot be removed or after trephining for the relief of intracranial tension.

The fungus cerebri is the result of some degree of infection of the brain which causes swelling and oedema of its substance. If this infection subsides and disappears, the brain gradually recedes, the area eventually healing over. This process of repair usually occupies several months. If on the other hand the sepsis extends further into the brain, or there is some deeply situated abscess or tumour, the herniation may increase to an alarming degree, and the patients usually succumb to spreading encephalitis or to an acute infection of the meninges. When there is no question of further surgical interference in order to find a causal lesion, the exposed brain should be kept covered with a spirit dressing or with gauze soaked in a 1 per cent watery solution of formalin. Lumbar or even ventricular puncture may be useful as a temporary measure. Shaving away the protuberant mass or compressing it with an elastic bandage have been recommended, but cannot have any curative effect while the brain sepsis persists. The patients should be given hexamine by the mouth so long as there is any discharge and especially if there is any escape of cerebrospinal fluid.

In the second variety, in which the scalp is intact, operative interference must be directed to closing the bony defect, but this cannot be contemplated if there is increased intracranial tension.

V.—MISCELLANEOUS HERNIAE

687.] Hernia of the lung, of muscle, and of the testicle are dealt with under the appropriate titles.

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HERPES

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Reference may also be made to the following titles:

BELL'S PARALYSIS CEREBROSPINAL FEVER
CHICKEN-POX

1.—HERPES ZOSTER

(*Synonyms.*—Zona; shingles)

(1)—Definition

688.] Herpes zoster is an eruption composed of grouped vesicles situated on an erythematous plaque. It occurs in the distribution of a cutaneous nerve segment and, with rare exceptions, is unilateral. It seldom recurs.

(2)—Aetiology

The eruption is due to an acute haemorrhagic inflammatory reaction in a posterior-root ganglion, and the distribution of the cutaneous lesion depends on the ganglion affected (Head and Campbell). The ganglion shows petechial haemorrhages and perivascular mononuclear infiltration. There may be inflammation of the primary sensory neurone

and localized posterior myelitis of the cord, and the cerebrospinal fluid shows a lymphocytosis.

*Relation
between
herpes zoster
and
chicken-pox*

It is uncommon for a patient with herpes zoster to communicate the condition to others. There is, however, considerable clinical evidence that herpes zoster may give rise to chicken-pox, and a common aetiological agent has been postulated for the two diseases. In support of this hypothesis it has been noted in several instances that inoculation of children with the fluid of herpes zoster vesicles has been followed by the appearance of a varicelliform eruption.

*Causal
organism*

Fluid from the early vesicles of herpes zoster is free from bacteria, and the nature of the causal virus is unknown. An attack of herpes zoster conveys a lasting immunity, and it is probable that it produces an immunity to varicella, and vice versa. Crossed fixation has been demonstrated with the convalescent serum of herpes zoster and varicella patients, and an emulsion of the crusts of herpes zoster vesicles shows complement fixation with convalescent herpes zoster serum.

Immunity

Some cases of herpes zoster appear to be secondary to intoxications (arsenic, bismuth, lead), nerve lesions (tuberculous foci, tumours, injury), or infections (syphilis, poliomyelitis). In these conditions the lesion primarily affects the posterior-root ganglia and may be caused either directly or as a result of the intoxication, infection, or injury creating conditions suitable to invasion by the specific virus of herpes zoster—indirectly. The appearance and course of the eruption in these cases are identical with those of the spontaneously occurring form.

Lewis suggested that the skin lesions could be produced by antidromic impulses passing down the sensory fibres from the affected ganglion and releasing in the skin substances of a histamine-like nature, which, by their action on the skin vessels, might ultimately be the cause of the eruption.

(3)—Morbidity Anatomy

Vesicles

The vesicles of herpes zoster are identical with those of chicken-pox. They are situated in the middle regions and base of the stratum mucosum (rete Malpighii) and are formed as a result of cloudy swelling and degeneration of the prickly cells and intercellular oedema. Polymorphonuclear invasion is a relatively late occurrence. The base of the vesicle becomes more or less necrotic, and this may be sufficient to lead to scarring.

(4)—Clinical Picture

Rash

The rash appears suddenly and is usually preceded by neuralgic pain in the area about to be affected. It begins as one or more erythematous patches, which soon become covered with firm deep-seated vesicles in close apposition and grouped in a grape-like formation. In severe cases the vesicles may be haemorrhagic. The vesicles become purulent in a few days and gradually dry up to form crusts. Erosion may take place under the crusts, and when these become detached shallow ulcers

*Crusting
and scarring*

may be seen. When healing takes place, superficial scarring may be left to mark the site of the lesion. Scarring, however, is not a constant feature. The eruption runs its entire course in two to four weeks, and during the first few days crops of fresh vesicles may appear. The distribution of the rash is always linear.

Sensations of burning and itching are almost always present in the affected skin, and there may be some degree of hyperaesthesia. Pain may be a prominent feature, especially in the elderly, and it may persist for weeks or months after the rash has disappeared. Swelling of the regional lymphatic glands may accompany the rash, and occasionally constitutional symptoms and fever are present at the onset. *Symptoms*

Herpes zoster occurs on any part of the body, but most often on the thorax and abdomen, where it may half encircle the trunk but does not cross the middle line. *Distribution on body*

A common site is in the distribution of the superior (ophthalmic) division of the trigeminal (fifth) nerve (trigeminal herpes); the lesions occupy the forehead and frontal region of the scalp, the upper eyelid, and the conjunctiva. Involvement of the conjunctiva is a serious complication, because ulceration is an almost certain sequel, and the risk of grave complications is considerable (see Vol. III, p. 430). *Trigeminal herpes*

When the geniculate ganglion is affected (geniculate herpes), the eruption may be accompanied by violent ear-ache, hyperaesthesia of the tongue, transient facial paralysis, deranged hearing, and giddiness (see VERTIGO). In some cases vesicles appear in the fauces. *Geniculate herpes*

(5)—Treatment

Locally, dusting the lesions with talc or starch powder and covering with cotton-wool are all that is required. Antiseptic pastes and wet dressings should be avoided, unless the lesions become secondarily infected. In ophthalmic herpes zoster cold compresses should be applied to the eye, boric acid irrigation carried out several times daily, and a 2 per cent solution of atropine sulphate instilled into the conjunctival sac twice daily. *Local treatment*

Aspirin should be given in the early stages to allay the pain, and morphine may be required for this purpose in severe cases. Injections of pituitary (posterior lobe) extract $\frac{1}{2}$ to 1 c.c. are useful in allaying the pain and cutting short the course of the eruption and may be given once or twice daily for the first few days. *Treatment of eye*

For persistent after-pain iodides and aspirin may be given, and diathermy or radiant heat is helpful. *Drugs*

2.—HERPES SIMPLEX

(*Synonyms.*—Herpes febrilis; fever blister; cold sore)

(1)—Definition

689.] Herpes simplex is a localized acute vesicular eruption, the vesicles occurring in groups.

(2) -- Aetiology

Causal organism

The eruption is caused by a specific filterable virus which is present in the vesicle fluid and has also been found in saliva and tears. Cutaneous inoculation of this fluid in man reproduces the lesions. After successive cutaneous inoculations of one strain in man a condition of insusceptibility develops towards this strain but not towards other strains. Corneal inoculation of a virulent strain of the virus in rabbits causes a local reaction, and an associated encephalitis may also be produced. The virus is capable of passing the more porous Berkefeld filters and, provided that it is contained in a broth medium, loses little of its infectivity. By filtration through graded collodion membranes, the size of the virus has been estimated to be between 0.1 and 0.15 μ (Ellford, Perdrau, and Smith).

(3)—Morbid Anatomy

Vesicles

The vesiculation occurs in the superficial part of the epidermis and is accompanied by necrosis and ballooning of the epidermal cells and intercellular oedema. In the superficial part of the dermis there are vascular dilatation and polymorphonuclear infiltration. Many of the epidermal cells show the acidophil intranuclear granules commonly associated with virus infections.

(4)—Clinical Picture

Eruption

Herpes simplex is usually preceded for an hour or two by tingling, itching, or burning sensations at the site to be affected. The eruption appears first as a red flush on which the blisters rapidly form in closely set groups, the lesions assuming the form of a bunch of grapes. They occur in groups and may cover a considerable area of skin. In contradistinction to herpes zoster, herpes simplex may be distributed bilaterally.

Crusting and scarring

The vesicle fluid is at first clear but rapidly becomes purulent and, in rare cases, haemorrhagic. The purulent vesicles become converted into a crust, which falls in eight to ten days from the onset of the lesion, leaving a temporary red flush marking the site of the lesion. Scarring does not occur, unless the lesion has been attended by an unusual amount of suppuration. Slight enlargement of the regional lymphatic glands may occur in severe cases.

Sites of eruption

The commonest site of the eruption is the face, particularly round the mouth and adjacent cheeks and nose. It also occurs on the genital regions and less commonly on other parts of the body and on the buccal mucosa. It rarely attacks two different areas simultaneously.

On the genital regions and mucous membranes the herpetic vesicles rapidly become eroded and covered with a fibrinous membrane, and superficial ulceration may occur with slight induration of the base and edge of the shallow ulcers. The grouping of the lesions in bunches, however, is maintained on these areas and is an aid to diagnosis.

An attack of herpes simplex confers only a short-lived immunity, and recurrences are almost the rule. In highly susceptible persons these may occur as often as twice monthly, and the tendency may persist for several years, causing much inconvenience. Recurrences often attack the same area of skin on each occasion.

Although herpes simplex is due to a specific virus, the eruption usually has a precipitating cause, the commonest being coryza. It often accompanies pneumonia, cerebrospinal fever (see Vol. III, p. 45, and Plate IV, facing p. 45), and encephalitis and may be present in any of the specific fevers. In recurring cases the eruption may be associated with sources of repeated mild trauma, peripheral irritation, or reflex irritation from some inflammatory focus in the neighbourhood, and in some instances emotional states may precipitate an attack.

Precipitating factors

(5)—Treatment

When the premonitory tingling preceding the eruption is felt, the outbreak may sometimes be prevented by the frequent local application of spirit of nitrous ether. When the lesion has developed, a 3 to 5 per cent solution of silver nitrate in spirit of nitrous ether or a 10 per cent solution of silver nitrate in water dabbed on the affected area usually cuts short the duration of the eruption by a few days but may be undesirable on account of the blackening of the skin. The early application of an ointment containing 1 per cent of ammoniated mercury and its continued use twice daily are also useful in reducing the length of the attack.

Local applications

Recurrences may be avoided in some cases by exposing the skin of the affected area to sparks from a high-frequency current, using a flat glass vacuum electrode, immediately after the eruption has disappeared. Vaccination of the subject on the buttock with the clear fluid obtained from the vesicles at the onset of the attack is also sometimes successful, as is vaccination with ordinary anti-smallpox calf lymph. Although none of these methods is certain to succeed, they are worth a trial.

Electrotherapy

Vaccination

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HETEROPHYES

See FLUKE INFECTIONS, INTESTINAL, Vol. V, p. 328

HICCUP

See DIAPHRAGM DISEASES, Vol. III, p. 673

HIDRADENOMA

See SKIN TUMOURS

HIDROCYSTOMA

See SKIN TUMOURS

HIP DISEASES AND INJURIES

See ARTHRITIS, Vol. II, p. 101; DISLOCATIONS AND FRACTURES,
Vol. IV, p. 152; *and* JOINTS, DISEASES AND INJURIES

HIRSCHSPRUNG'S DISEASE

See MEGACOLON

HISTOPLASMOSIS

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Reference may also be made to the following title:

RETICULO-ENDOTHELIAL SYSTEM DISEASES

1.—DEFINITION

(*Synonym.*—Cytomycosis)

690.] Histoplasmosis is a fatal disease due to generalized infection of the reticulo-endothelial system with a yeast-like organism, *Histoplasma capsulatum*; clinically it is characterized by splenomegaly, anaemia, emaciation, remittent temperature, and perhaps pulmonary and other features.

2.—AETIOLOGY

Incidence

Cases have been recorded from Panama, the United States of America, and Java. Negroes, Chinese, and Europeans have been affected, and infants and children as well as adults may manifest the disease. Most of the recorded cases are in males. The mode of acquiring the disease is unknown.

The causal agent, *Histoplasma capsulatum*, is closely related to *Cryptococcus farciminosus*, the cause of epizootic lymphangitis of horses and man.

Histoplasma capsulatum, described by Darling (1906), is a yeast-like organism, oval or round in shape, with a diameter of 1 to 4 μ and possessing a thick capsule (see Fig. 80). It has been cultured on Sabouraud's medium and blood agar by De Monbreun and appears both as a yeast-like form and as a mycelium; intravenous inoculation of the yeast-like cultures into monkeys (*Macacus rhesus*) produces a fatal infection within two weeks.

3.—MORBID ANATOMY

Necropsy may reveal disseminated whitish granulomas in the lungs, enlargement of the liver with localized or diffuse arborescent greyish necrotic lesions and cirrhosis, considerable splenomegaly, enlargement of the abdominal, thoracic, or even cervical lymphatic glands, and numerous small ulcers involving the small intestine and colon.

The intestinal lesions vary from 0.2 to 2.0 cm. in diameter and show hyperplasia, necrosis, ulceration, and haemorrhage at different stages (Darling, 1908). Puckered pigmented scars may mark the site of former ulcers. Microscopical examination of the tissues reveals enormous quantities of the yeast-like organisms packed within the reticulo-endothelial cells of the lung, liver, spleen, intestine, lymphatic glands, and bone marrow. Dodd and Tompkins believed that the part played by the large mononuclears in the plugging of blood-vessels, in the collapse of the alveoli of the lung, in the massive invasions of the bone marrow, and in the destruction of red cells explained many of the symptoms of the disease.

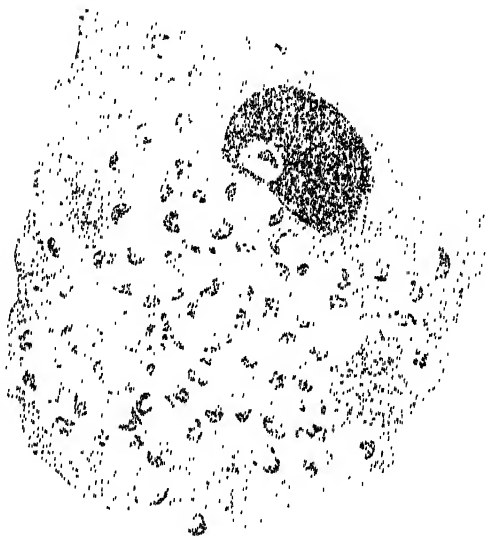


FIG. 80.—*Histoplasma capsulatum* in macrophage from smear of human lymphatic gland. $\times 2000$. (From *Protozoology*, by C. M. Wenyon)

Macro-
scopical

Micro-
scopical

4.—CLINICAL PICTURE

The onset is gradual, and chronic cough may have been present for *Symptoms* years. Early symptoms include generalized pains, remittent fever, anaemia, emaciation, lassitude, and weakness. Anorexia, abdominal pain, and vomiting may be present, and diarrhoea with or without blood or mucus may be complained of. Pulmonary features with chronic

cough and haemoptysis may supervene and the terminal stages be characterized by cyanosis and dyspnoea. Oedema, jaundice, hydrothorax, and ascites have been recorded.

*Physical
signs*

Physical examination generally reveals enlargement of the spleen and perhaps of the liver as well, and signs of patchy consolidation may be found in the lungs. Enlargement of the superficial lymphatic glands is not common, but well marked cervical adenopathy simulating Hodgkin's disease (see p. 528) has been recorded. In another case reported by Crumrine and Kessel an abdominal mass was palpated, which at necropsy was found to be caused by enlarged mesenteric lymphatic glands. The spleen in this case was not clinically enlarged.

*Blood
picture*

Blood examination may show a well marked reduction of red cells and haemoglobin, with the appearance of regenerative forms in the peripheral blood. In the absence of septic complications the leucocytes appear to be decreased in number.

5.—COURSE AND PROGNOSIS

The course of the disease varies from several months to many years, but all the recorded cases have terminated fatally.

6.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

The condition should be borne in mind in any obscure case of splenomegaly associated with fever. Enteric fever, abdominal or pulmonary tuberculosis, Hodgkin's disease, and torulosis and other systemic fungous infections, e.g. coccidioidal granuloma (see Vol. II, p. 405), may be simulated. The diagnosis may be made by demonstrating the yeast-like fungi in the mononuclears in peripheral blood smears, by blood culture, or in cultures from material obtained by liver, spleen, or bone marrow puncture.

7.—TREATMENT

In the absence of specific drug therapy treatment appears to be purely symptomatic.

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HODGKIN'S DISEASE

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Reference may also be made to the following titles:

GLANDULAR FEVER	LYMPHATIC GLANDS DISEASES
LEUKAEMIA	RETICULO-ENDOTHELIAL SYSTEM DISEASES

1.—DEFINITION

(*Synonyms*.—Lymphadenoma (Wunderlich, 1866); lymphadenoma malignum; malignant lymphoma (Billroth); Hodgkin's lymphogranuloma (Turnbull); Hodgkin's granuloma (Ewing); lymphogranuloma malignum; lymphomatosis granulomatosa (Fraenkel and Much, 1910); adénie (Trousseau, 1865).)

691.] Lymphadenoma is usually a chronic, rarely an acute, hyperplastic change of a special character occurring in lymphoid tissue. Probably

due to a virus, it is often accompanied by fever and may present features resembling those of malignant growth. So far it has been uniformly fatal, although well marked remissions may occur in its course.

Nomenclature Virchow (1864) called it lymphosarcoma, but this term, being applied to another growth of quite different structure, is confusing and is no longer used. Cohnheim (1865) described as pseudoleukaemia cases showing the histological changes in the lymphatic glands but not the blood picture of leukaemia. Lymphadenoma is probably the name in most common use in Great Britain, but it has the disadvantage that in some other countries it is used in much the same sense as lymphoma, a non-committal term for a much less serious adenopathy.

2.—AETIOLOGY

Incidence Lymphadenoma is widely distributed over the globe and, though commoner in childhood and early adult life, may occur at any age. It is twice as common in males as in females, is not hereditary, and only in extremely rare instances, such as those reported by Gow and those collected by Arkin and by McJaffy and Peterson, has more than one case been reported in the same family.

In England and Wales during the period 1931 to 1935 the average number of fatal cases was 554 per annum (357 males and 197 females); in the previous five-year period 1926 to 1930 it was 461 per annum (292 males and 169 females). There thus appears to be some increase in the mortality of this disease; and this impression is borne out even when allowances have been made for the increase and the change in age distribution of the population.

The well known Hodgkin's disease of domestic animals would appear to be distinct from lymphadenoma histologically; in only very few cases, e.g. in a dog (MacMahon) and a rabbit (Medlar and Sasam), has the diagnosis of lymphadenoma of the human type been confirmed microscopically. The human disease has not been communicated with certainty to experimental animals.

3.—PATHOGENY

Reticulosis There has been much discussion whether the condition is inflammatory and a granuloma, or a new growth (a view emphasized by van Rooyen, 1937), or a transition between the two. It is a hyperplasia of the reticulo-endothelial system, a fibromyeloid reticulosis, and so involves first and chiefly the lymphatic glands, spleen, liver, and bone marrow. At first local, it progressively extends and eventually may, when it takes on malignant characters ('Hodgkin sarcoma'), invade other tissues, such as muscle and bone.

Relation to tuberculosis In the past it has been argued that it is a special form of tuberculosis (Sternberg, 1898; Fraenkel and Much, 1910, 1923); but the production

of tuberculosis by inoculation of affected glands into animals has been reasonably explained as due to a secondary tuberculous infection of the glands used in the experiment (Andrewes, 1902). It has also been suggested that infection with avian tuberculosis is responsible (L'Esperance, 1931), but this has been firmly contested (van Rooyen, 1933). Other infections have been suggested—e.g. spirochaetes (White and Proeschner, 1908) and a pleomorphic diphtheroid bacillus (Yates and Bunting, 1917). These suggestions have not been confirmed. As the result of a long-continued investigation M. H. Gordon and his co-workers on the Rose Research on Lymphadenoma at St. Bartholomew's Hospital, London, have eliminated the above infections and brought forward very strong evidence that an agent of the virus class is the responsible factor. Gow (1934) found that a vaccine prepared from lymphadenomatous glands and containing Gordon's elementary bodies ('E.B.'; see Fig. 81) gave rise to reactions; and Warner (1937) showed that in certain cases a sensitized vaccine of these bodies exerted a well marked beneficial effect.

Possibly a virus

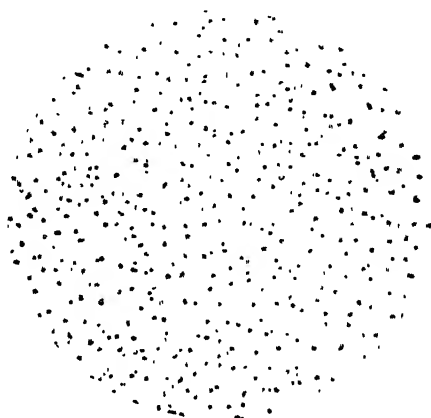


FIG. 81.—Elementary bodies from a broth suspension of lymphadenoma gland. Stain Giemsa. $\times 1250$. (From the *Rose Research on Lymphadenoma*, by M. H. Gordon)

Lymphoblastoma

Hodgkin's disease has been regarded as a member of the lymphoblastomas, in company with lymphoid leukaemia, lymphocytoma, lymphosarcoma, pseudo-leukaemia, and mycosis fungoides, the type-cell of which is the lymphoblast. According to Mallory Hodgkin's disease is the scirrhus type of lymphoblastoma. Warthin also regarded Hodgkin's disease and leukaemia as neoplasms. Cases occur which may resemble Hodgkin's disease in some clinical features, but in which the histological appearance of glands is atypical and the biological test (see p. 532) negative.

4.—MORBID ANATOMY

In the early stage the glands are fairly soft and on section are greyish in colour. Pronounced fibrosis follows so that the glands become hard, thus contrasting with the uniform softness of lymphosarcomatous glands. The capsule of the glands remains intact but is usually thickened, and the glands do not form confluent masses, at any rate until a late stage or as a result of secondary infection or therapeutic irradiation. Although small yellow areas of necrosis occur, these do not, in cases

Glands

free from tuberculous infection, show the massive caseation characteristic of ordinary tuberculous adenitis. Amyloid change, though far from common, may occur without the more usual factors of prolonged suppuration and syphilis.

Spleen The spleen when enlarged contains white masses of yellowish-white lymphogranulomatous tissue originating from the Malpighian bodies, a condition described as the 'hard-bake' spleen. These masses resemble areas of tuberculous caseation but, unlike them, never soften in the centre, are more peripheral in distribution, and are more easily seen through the capsule.

Liver The liver is affected in about half the cases and then usually shows in the portal spaces small areas somewhat resembling those in the spleen; in exceptional cases there is definite portal cirrhosis which, though it may be a coincidence, has been thought to be due to fibrosis of the lymphadenomatous tissue like that of the lymphatic glands; Steiner recorded such a change in a case which had been treated by X-rays.

Kidneys Much less often the kidneys contain discrete nodules, massive infiltration being extremely rare. Diffuse infiltration of the kidney has been associated with retroperitoneal lymphadenomatous glands (Labbé and Balmus). Although the lymphatic glands in front of the aorta and in the mesentery are often affected, Peyer's patches and the lymphoid follicles of the stomach and intestine are very seldom involved. In very rare cases primary Hodgkin's disease of the stomach has been described from histological examination (Thompson and Howells). In exceptional instances perforation of the intestine, presumably from ulceration of the lymphogranulomatous tissue, has been recorded. Many of the cases formerly described as lymphadenoma of the gastro-intestinal tract would now come under another heading, such as lymphosarcoma or lymphocytoma.

Lungs The lungs are more often affected than is generally recognized. According to Versé they are involved in 40 per cent of the cases in one of the following forms, whether primary or secondary: mediastino-bronchial invasion, diffuse invasion of the lung, and miliary and lobar infiltration. The peribronchitic form is one of the commonest. Cavities may form in massive infiltration of a lobe.

Bone marrow The bone marrow often shows lymphogranulomatous infiltration; this may be latent and quite unsuspected, as has been revealed by radiography; statistics show that it occurs late in the course of the disease and in from a quarter to half of all cases. Another way in which the skeleton is invaded, especially the spine, sternum, and pelvis, is by direct extension from adjacent glands already infected; the bodies of the vertebrae when thus infiltrated may collapse, but the intervertebral discs are rarely destroyed. Considerable gibbosity (angular deformity), compression of the spinal cord and nerve-roots, pain, and paraplegia may thus result.

Spine

5.—HISTOLOGY

In the earliest stage there is said to be lymphocytic proliferation; but, if so, this is soon succeeded by pleomorphic proliferation of the reticulo-endothelial system, especially with the production of large clear cells with single, double, or multiple nuclei, the first of which resemble those

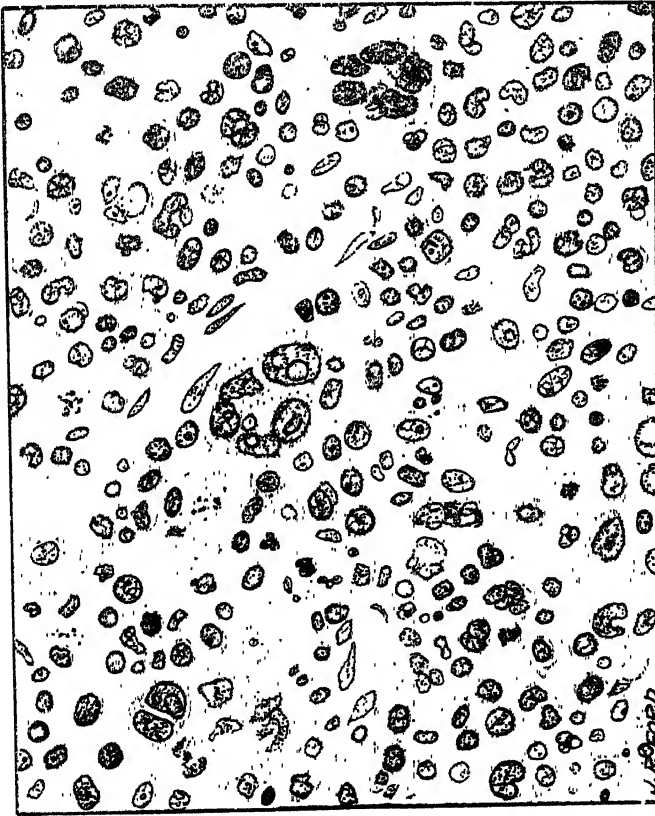


FIG. 82.—Hodgkin's disease. A typical field in a lymphatic gland. ..560.
(Pullinger, *Rose Research on Lymphadenoma*)

in tuberculous large-celled hyperplasia of lymphatic glands (see Fig. 82). The characteristic 'lymphadenoma cell', a multinuclear giant cell, quite different from the tuberculous giant cell, was described by Virchow, Greenfield, Sternberg, and Dorothy Reed, and is often called after one or other of these pathologists. Eosinophil cells, as pointed out by Goldmann in 1892, are much increased in number; this local eosinophilia is probably due to cells formed in the bone marrow and attracted by chemiotaxis to the glands. Pullinger, however, has found evidence of *Eosinophilia*

Sarcomatous change

their local origin. Plasma cells may also be present. Small areas of necrosis occur, and with the passage of time progressive fibrosis occurs. In some cases the lymphogranuloma undergoes a sarcomatous change, and 'Hodgkin granuloma' becomes 'Hodgkin sarcoma', which Ewing compared to the sequel of squamous-celled carcinoma in lupus vulgaris. In three out of Hodgkin's original seven cases histological examination in 1926 showed the characteristic changes (Fox).

6.—CLINICAL PICTURE

The onset of lymphadenoma is nearly always gradual, and usually slight enlargement of the superficial lymphatic nodes above the clavicle, in the posterior triangle of the neck, in the axilla, or groin is detected before symptoms of malaise, undue fatigue, loss of weight, anaemia, or dyspepsia are noticeable. The enlargement begins on one side and subsequently becomes bilateral.

Glands

The affected glands are round, smooth, discrete, freely movable, seldom tender or painful, and not adherent to each other or the skin, unless there has been a secondary infection, pyogenic or tuberculous. The largest nodes tend to lie towards the centre of the mass; those at the periphery may be small and even shotty. The supraclavicular, axillary, and inguinal glands are those most often clinically obvious, but enlargement may appear first in other positions, for example, the epitrochlear gland at the elbow. When glands at the root of the neck or in the axilla are involved in a morbid process, palpable enlargement of glands lying on the costocoracoid ligament below the clavicle has been found to be an important differential diagnostic sign in favour of Hodgkin's disease.

Enlargement of the superficial lymphatic nodes may disappear under treatment, entirely or partially, for a time, while insidious enlargement of the deep nodes progresses and the patient becomes anaemic, emaciated, and goes steadily downhill. Similar and temporary diminution or even disappearance of glandular enlargement may follow acute infections, such as erysipelas, lobar pneumonia, or influenzal pneumonia; that improvement may also occur in these circumstances in leukaemia is of interest in connexion with their common membership of the lymphoblastoma group, with Symmers's view that Hodgkin's disease and myeloid leukaemia are 'probably different quantitative responses to the same type of provocative agent', and with W. B. Coley's treatment of Hodgkin's disease by the mixed toxins of erysipelas and *Chromobacterium prodigiosum* and by the application of radium.

Blood

In the earlier stages there may be no change in the blood, but later a progressive secondary anaemia develops. It has been stated that the degree of anaemia runs parallel with the hepatic enlargement. In the late stages it may become so severe as to require blood transfusion. This anaemia may in different cases be explained by one or more of the

following agencies: toxæmia, invasion of the bone marrow by lympho-granulomatous growth, the effect of repeated X-ray exposures, and exhaustion of the bone marrow from long-continued arsenical medication.

The white count varies so much that there is no characteristic or diagnostic picture; cases were divided by Roth and Watkins into four groups according to their duration and their differential counts. In some cases, especially when the disease is generalizing, there is a polymorphonuclear leucocytosis; in other cases, perhaps particularly in association with fever or considerable splenomegaly, there is leucopenia with a relative lymphocytosis. There may also be an increase in the monocytes. In some instances there is a high eosinophilia, even above 60 per cent. This hæmic eosinophilia, seen particularly in the rare acute cases, may be associated with itching; but eosinophilia and itching may occur independently of each other. Megacaryocytes, apparently on their way from the bone marrow to form the giant cells in the glands, have been seen in the blood-stream (Symmers). Among

White count

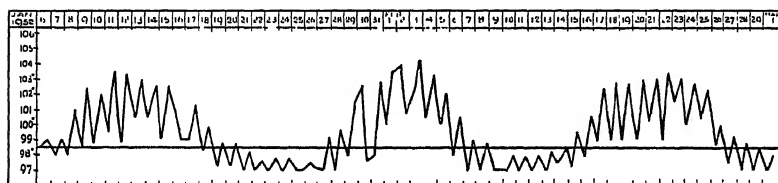


FIG. 83.—Remittent fever of Pel-Ebstein type

41 cases 24, or 58 per cent, showed on blood culture a hæmolytic micrococcus, which may have the same relation to the real cause of lymphadenoma that Pfeiffer's bacillus has to the virus of influenza (Peretz, Newler, and Funstein).

The erythrocyte sedimentation rate is much increased, especially in cases which are pyrexial; this may be a point of diagnostic importance (Gow).

Sedimentation rate

Though some cases are apyrexial throughout, as pointed out by Gowers, fever is very common at some stage of the illness, and at least three forms of pyrexia may occur. The most striking is that of relapsing fever, present in one of Hodgkin's original cases, and recorded by Wunderlich, Murchison (1870), Osler, Pel, and Ebstein, and often called the Pel-Ebstein type (see Fig. 83). It is characterized by intermittent fever, often of a swinging character, separated by apyrexial periods in which the temperature may be very low. The waves of pyrexia occur regularly, the span from the middle of one febrile period to the middle of the next in different patients varying usually between fifteen and twenty-five days; it is generally the same in the individual (Hall and Douglas). During the febrile periods the lymphatic glands and spleen may increase in size, and from this change in the lymphatic glands in the porta hepatis (transverse fissure) jaundice and ascites may result. Bouts of pruritus may coincide with the waves of fever. The Pel-Ebstein fever may occur when the internal lymphatic glands only are involved, and so the

Fever

Pel-Ebstein type

diagnosis may be very difficult. The causation of this relapsing fever is obscure; proof of a secondary infection is wanting, but possibly it is due to sensitization to protein absorbed from necrotic lympho-granulomatous foci or to a virus septicaemia.

Skin Cutaneous manifestations of one kind or another have been estimated to occur in 25 to 39 per cent of the cases. Itching, thought to be toxic in origin, is the commonest, and the resulting scratching is responsible for the frequent eruptions of a prurigo-like character, eczematization, and lichenification. It may be an early symptom, before any glandular enlargement is obvious or suspected, and accordingly the patient may first seek advice from a dermatologist. It may be continuous or more often paroxysmal and coincide with the bouts of fever; the distribution may be localized or more commonly general; and the association with haemic eosinophilia has been insisted on by Favre and others of the French school. The resulting scratching paves the way for pyogenic lesions of the skin. Profuse sweats during sleep are common and may accompany the itching.

Pigmentation Pigmentation may be the result of prolonged treatment by arsenic or irradiation; or it may be due to pruritus and scratching, or possibly, when more noticeable on the abdomen, to stimulation of the sympathetic by enlarged retroperitoneal lymphatic glands. Other rashes, perhaps toxic in origin, are occasionally seen: erythematous, morbilliform, urticarial, papular, bullous, and generalized exfoliative dermatitis. *Herpes zoster* Herpes zoster may occur and be due to invasion and irritation of the posterior nerve-roots by lymphadenomatous growth, but it may be due to arsenic taken medicinally. The white scars sometimes left by the herpetic vesicles may stand out on the background of pigmented skin.

A distinction should be drawn between (i) lymphogranulomatous growths in the skin, which are rare, much more so than in leukaemic infiltration of the skin, and (ii) non-specific eruptions of a prurigo-like nature, composed of small round cells and due to the scratching induced by pruritus.

Nervous symptoms Pressure on nerves may cause pain or paralysis, for example abductor paralysis when the recurrent laryngeal nerves are involved. Pressure on the cervical sympathetic may cause enophthalmos, pseudoptosis, contraction of the pupil, and occasionally disturbance of perspiration. In very rare instances encephalo-meningeal symptoms have been reported (Barker, 1934); Murchison (1869) recorded convulsions and delirium, and transient paraplegia has been observed. Invasion of the spine by lymphadenomatous growth has caused pain and paraplegia; but possibly arsenical neuritis has, at any rate in the past, been an occasional cause of loss of power in the limbs.

Clinical forms The situation of the main enlargement of the lymphatic glands—in the neck, chest, or abdomen—makes it convenient to describe the following clinical forms:

Primary in neck (i) Primary glandular enlargement in the upper part of the neck, due possibly to the entrance of the causal agent from the mouth or

throat, may give rise to a collar-like mass under the jaw. Enlarged glands above the level of the clavicle may be an extension of a primary mass in the chest.

(ii) Hodgkin's disease starting in the chest is probably commoner than is generally realized; the chief site may be in the mediastinal and tracheal glands or in the thymus, and so the pericardium, the pleura, or the lung may become involved. The signs and symptoms—dyspnoea, cyanosis, cough, venous engorgement—may be those of an intrathoracic tumour, of a pleural effusion which may be chylous or chyliform, and even of a pericardial effusion. Cough and haemoptysis, especially in association with pain in the chest, fever, and absence of enlarged superficial lymphatic nodes, may suggest early pulmonary tuberculosis. The fingers and toes may be clubbed (Kidd and Turnbull), and chronic pulmonary osteoarthropathy has been recorded (Weber and Ledingham). Pressure may cause abductor paralysis, dysphagia, or venous obstruction. In all cases in which Hodgkin's disease is suspected, an X-ray examination should be carried out to determine whether the mediastinal glands are enlarged. *Intrathoracic*

(iii) Abdominal manifestations vary; enlargement of the glands at the back of the abdomen and in the mesentery, without obvious hepatic and splenic change, may render the diagnosis extremely difficult. But the glands in the groin may be enlarged and, like glands at the level of the clavicle, be the outward evidence of deep-seated primary disease. In the peritoneal form the mesenteric glands are generally involved, and ascites, which may imitate that of tuberculous peritonitis, has occasionally been chylous or pseudo-chylous. Enlargement of the glands in the porta hepatis (transverse fissure) may cause obstructive jaundice, which may come and go with the febrile periods of the Pel-Ebstein syndrome. Dyspepsia and abdominal pain are present in some cases. Pressure exerted by enlarged abdominal glands on the lacteals may interfere with intestinal absorption and lead to a sprue-like syndrome (Fairley and Mackie). *Abdominal*

The spleen is enlarged in 75 per cent and the liver in 50 per cent of the cases, so that hepato-splenomegaly is not uncommon. In a few instances the spleen alone is enlarged and so much so that a special splenic form has been described. In very rare instances a similar hepatic form has been recorded which may imitate malignant disease or, when associated with fever, suggest hepatic abscess or tertiary syphilis. *Spleen and liver*

The acute form of Hodgkin's disease has a sudden onset with fever and pains in the limbs. Splenomegaly develops in the course of a few days and often precedes enlargement of the superficial lymph nodes. *Acute form*

7.—COURSE AND PROGNOSIS

The course varies considerably. Usually a chronic condition lasting on an average, when untreated, about two and a half years, it occasionally *Course*

is clinically acute, especially in children. The relapsing form, with fever of the Pel-Ebstein type, which persists until the end, is subacute, and averages about seven months (Batty Shaw).

Cause of death Death may be due to a secondary infection, especially tuberculosis, to mechanical interference with respiration, or, most often, to toxæmia, anaemia, and cachexia.

Prognosis Hodgkin's disease, unlike tuberculosis, does not undergo spontaneous cure, and up till the present all cases have been eventually fatal.

Survival period Although the average duration of life without treatment has been estimated to be two to two and a half years, there is considerable variation in the survival period, which may in exceptional instances be more than ten years. The outlook is obviously better when the disease is localized and worse when it is generalized and accompanied by fever.

Effect of irradiation Divergent opinions have been expressed on the question whether or not irradiation really prolongs life. Although the patients are made more comfortable and able to return to work for a time, some authorities doubt if life is prolonged. On the other hand, Leucutia from an analysis of 805 collected cases found that irradiation prolonged the survival period from two to three and a half years and that in different series there was a survival period of five years in 15 to 33 per cent and of ten years in 8 per cent. Although the elderly are not so often attacked as young adults, their response to treatment is very inferior, so that in them the disease may run a more rapid course (Labbé and Balmus).

8.—DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

Clinical diagnosis may be difficult, especially in cases in which the superficial lymphatic glands are not enlarged. When they are palpable, reliance should be placed on the following:

Biopsy (i) Biopsy, which is now a routine for a certain diagnosis. Unfortunately a gland excised from a case of Hodgkin's disease does not always show the characteristic changes; it may be enlarged from simple non-specific inflammation or from hyperplasia to compensate for the destruction of lymphoid tissue elsewhere. It has been recommended that a small hard gland should be selected for microscopical examination. In some cases a positive opinion is not justified, as the histological changes are not typical. In atypical cases an appeal can now be made to M. H. Gordon's biological test.

Gordon's test (ii) Gordon's test. A suspension of a gland removed aseptically from a case of Hodgkin's disease produces, when injected into the cerebrum of a rabbit, an encephalitic condition of ataxy, spasm, and paralysis, which often is fatal. This reaction does not follow similar intracerebral injection of an emulsion of glands affected with tuberculosis, inflammation, leukaemia, sarcoma, or carcinoma. The accuracy of this test has been confirmed by van Rooyen, Chapman, Uhlenhuth, and others. Friedemann contested the specificity of the test, as a similar encephalitic

agent is present in normal human bone marrow, leucocytes, and spleen. Chapman considered that a negative response was not of any value.

Differential diagnosis entails exclusion of a number of other conditions. Tuberculous adenitis in its early stage, before the glands have become adherent to the skin, matted to each other, or softened down, may present great difficulties, unless a biopsy is undertaken. In tuberculous adenitis the largest gland is often at the end of the chain. In the later stages the characters just mentioned point to tuberculosis. The rare condition of generalized tuberculous adenitis, described by Hilton Fagge (1886) and MacNalty (1911), may clinically closely imitate Hodgkin's disease, for relapsing fever may occur in both. Concomitant pulmonary tuberculosis would be in favour of tuberculous adenitis, whereas splenomegaly would point to Hodgkin's disease.

*Differential
diagnosis
From
tuberculous
adenitis*

Other forms of reticulosis should be recognized by the histological picture shown by a biopsy and a negative Gordon test. Brill, Baehr, and Rosenthal (1924) described under the heading of splenomegalia lymphatica hyperplastica, a condition of lymphatic follicle hyperplasia which was extremely susceptible to irradiation. Bodley Scott and Robb-Smith collected nineteen cases of lymphoid and fibrillary reticulosis.

*From other
forms of
reticulosis*

Lymphosarcoma is fortunately rare, but clinically when generalized it may be so like Hodgkin's disease that the diagnosis must depend on a biopsy and when necessary Gordon's test.

*From lympho-
sarcoma*

Secondary growths in the supraclavicular glands may be due to intra-thoracic or intra-abdominal disease. A malignant hypernephroma of the left kidney with metastases above the left clavicle has been responsible for an erroneous diagnosis of Hodgkin's disease. When the spleen is much enlarged and the superficial lymphatic glands are not enlarged, chronic splenic anaemia and subacute bacterial endocarditis must be excluded. Among other tumours in the neck account must be taken of metastases of carcinoma of the oesophagus, thyroid, and other parts, and of the 'potato' tumours, primary in the carotid body and slow growing, which, however, are very seldom bilateral.

*From
metastases*

Glandular fever or infectious mononucleosis is, compared with the ordinary cases of Hodgkin's disease, a short illness, lasting weeks rather than several months. It occurs in small epidemics and is associated with sore-throat and often with haematuria and anaemia. Difficulty will chiefly occur in distinguishing it from possible cases of acute Hodgkin's disease with a sudden onset, but in such cases a biopsy may be decisive (see Vol. V, p. 561).

*From
glandular
fever*

Boeck's multiple sarcoid, previously described as Mortimer's disease, after the patient, by Jonathan Hutchinson, is a chronic granuloma which may involve the lymphatic glands, skin, lungs, and bones of the hands and feet, the bony changes resembling those of leprosy rather than those of tuberculosis. The histological changes in the lymphatic glands are like those of tuberculosis, but acid-fast bacilli have not been found. It has been thought that the disease is related to tuberculosis in a way similar to that of Hodgkin's lymphogranuloma to tuberculosis,

*From Boeck's
multiple
sarcoid*

and in the absence of bony changes the clinical diagnosis, before examination of a gland, was, in most of the seventeen cases collected by Longcope, Hodgkin's lymphogranuloma.

9.—TREATMENT

Arsenic

Arsenic by the mouth, in increasing doses of arsenical solution starting with 3 minims and increasing up to 15 minims three times a day after food, was for years the routine treatment. Sodium cacodylate, in doses from $\frac{1}{4}$ to 1 grain, has been given intramuscularly, and the organic arsenical preparations have been given intravenously. Arsenic has been most successful in temporarily reducing the size of the glands, but unfortunately the disease becomes resistant to it.

Irradiation

Irradiation by X-rays or radium has largely superseded the oral administration of arsenic. The immediate effects of irradiation are remarkable; soft glands seem to melt away, the accompanying symptoms are relieved, the intermissions are prolonged, and ordinary life can be resumed. But when the relapse occurs, irradiation, like arsenical treatment, is less successful, for the disease tends to become tolerant to irradiation, or the body's powers of resistance fail. Hard glands, being so largely composed of fibrous tissue, do not respond to irradiation, and deep-seated Hodgkin's disease is not influenced to the same extent as superficial glands by X-ray treatment.

Radium has been thought to be more satisfactory than X-ray exposures, provided that all the lymphatic areas, and not only those obviously affected, are irradiated (Simmons and Benet, 1917). Encouraging results as regards prolongation of life were obtained by W. B. Coley from injection of his mixed toxins of erysipelas and *Chromobacterium prodigiosum* and the application of massive doses of radium.

Surgical operation

Surgical removal of the enlarged glands, formerly much used, has now been generally discountenanced and has been thought to favour generalization.

In primary Hodgkin's disease of the stomach partial gastrectomy has given good results (Thompson and Howells).

Specific treatment

It was found that a centrifuged suspension of lymphadenoma gland, attenuated by various means, especially by heating to 56° C. for half an hour, diluted to 1 in 50,000, and containing elementary bodies, produced a reaction, malaise, and mild pyrexia, when given hypodermically in some cases of Hodgkin's disease. The reaction appears to be due to a hypersensitive condition of the patient. When the autogenous gland suspension has been flocculated by antiserum specially prepared against it by immunizing rabbits, the flocculi so formed are found microscopically to consist largely of agglutinated elementary bodies. These flocculi, after being deposited by centrifuge and well washed in five or six changes of saline, have now been tried as a sensitized vaccine; small doses are advisable, for reactions shown by

fever, itching, and temporary enlargement of the glands are readily produced. This treatment has given encouraging results in some early cases in young adults but has not succeeded in patients with secondary infections or in the Pel-Ebstein syndrome. Attempts are being made to improve the method, and, as a considerable number of the elementary bodies escape flocculation on a single exposure to the antiserum, the effect is being tried of submitting them to two flocculations in succession and diluting the vaccine thus doubly sensitized to 1 in 100,000.

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HOOKWORM DISEASE

See ANKYLOSTOMIASIS, Vol. I, p. 587

HORNS

See CORNS AND BUNIONS, Vol. III, p. 434; *and* SKIN TUMOURS

HYDATID DISEASE

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Reference may also be made to the following titles:

BRAIN TUMOUR

CYSTICERCOSIS

1.—DEFINITION

(*Synonym.*—*Ecchinococcosis*)

692.] This disease is due to the development in the human subject of the cystic or larval stage of *Echinococcus granulosus* (Batsch), a small cestode, the natural habitat of which is the small intestine of the dog.

2.—LIFE-CYCLE

The adult worm measures up to 6 mm. in length and has three or four segments, of which the terminal one carries from 500 to 800 ova in various stages of development. The worms may be present in thousands in an infested dog (see Fig. 84), and the intact or disintegrated segments are shed in the faeces. *Adult worm*

The ova, approximately 45 μ in length, are, like those of the other cestodes, surrounded by a chitinous envelope and are extremely resistant to exposure. They may be ingested by the correct intermediate host in which the cystic stage of development takes place. The ovum hatches in the upper alimentary canal, liberating an active hexacanth embryo *Ova*

which bores through the wall of the intestine and then, after entering a radicle of the portal vein, is carried to the liver, in which it usually comes to rest and its typical further development occurs (Dévè, 1916; Dew, 1922).

*Development
of the cyst*

At first there is an active cellular reaction on the part of the host's defences, mononuclear and eosinophil cells surrounding the parasite within a few hours. This reaction sometimes overwhelms the parasite, which then undergoes disintegration and phagocytosis. In favourable conditions, however, it grows rapidly and with the same dramatic change that characterizes all embryonic growth, so that at the end of

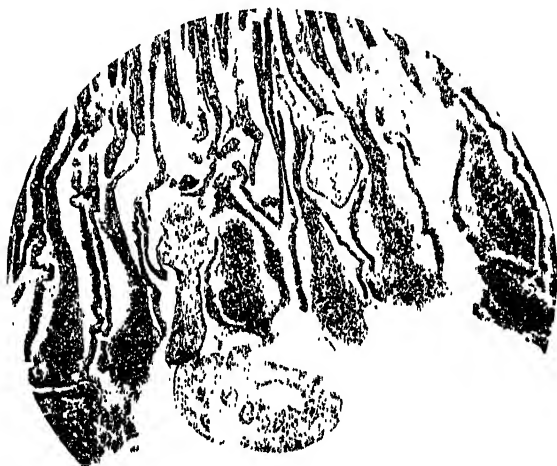


FIG. 84.- Section of ileum of dog, showing *Echinococcus granulosus*

three weeks it shows vacuolation, with the elaboration of specific fluid and a protective laminated hyaline wall. As the parasite grows, the cellular reaction of the host dies down, probably coincident with the development of the semi-permeable laminated cuticle of the parasite and the consequent cessation of leakage of specific protein. The leucocytes which surround the follicle are gradually succeeded by fibroblasts, and toleration of the parasite by the host is established. At the end of three months the cyst is nearly a centimetre in diameter, and at the end of a year a cyst approximately 5 cm. in diameter, surrounded by a tough avascular adventitia, is present. This adventitia, composed of simple avascular fibrous tissue, is similar to that developed round any relatively inert body; it merges gradually into the surrounding host tissues, and varies in thickness from a few millimetres to several centimetres, this depending mainly on the age of the parasite. Calcareous changes are relatively common, and an irregular pouching, due to growth taking

place along lines of least resistance, often occurs. The enclosed parasite is not adherent to the adventitia and can readily be removed in uncomplicated cases.

The fully developed univesicular cyst consists of a parasitic wall composed of an outer laminated membrane and an inner thin cellular germinal layer enclosing specific hydatid fluid. The laminated layer is composed of regular laminae of hyalin, which are laid down from within outwards by the nucleated germinal membrane lining its inner aspect. It is very elastic, tends to turn inside out when torn, and serves as a support for the cyst, to retain the specific fluid at a fairly high tension, and to protect the cyst from the entry of noxious substances. The specific hydatid fluid is formed by the germinal membrane and normally is clear, containing little or no protein and up to 0.2 per cent sodium chloride, and acts as a protective and nutritive medium for the developing scolices. (See Fig. 85.)

The scolices, or future worm-heads, are only found in mature cysts and are

a sign of completed biological development. They are produced inside brood capsules from the germinal membrane and may be present in thousands in a single cyst. They measure up to 160μ in the resting state, being just visible to the naked eye, and are seen in all stages of development, from the undifferentiated cellular bud to the fully developed scolex with suckers, hooklets, and contractile tissue. The life-cycle is completed when, swallowed by the dog, they become active and rapidly develop into adult worms.

Daughter-cyst formation is often noticed in man and occasionally in animals. This, in its typical endogenous form, consists of the development within the confines of the original mother-cyst of numerous replicas of the primitive cyst, producing the so-called multivesicular cyst. There has been much controversy about the reason for this development, but probably it should be regarded as due to some interference with the integrity of the original cyst, i.e. it is a protective phenomenon, the germinal elements being stimulated by adverse conditions to

*Fully
developed
cyst*



FIG. 85.—Section of wall of hydatid cyst showing laminated adventitia and germinal membrane, brood capsules, and scolices

Scolices

*Daughter-
cysts*

elaborate a second protective cuticle in order that the development of the reproductive elements may go on (Dévé, 1918; Dew, 1925).

3.—AETIOLOGY

Although the worm has been rarely found in other members of the canine species, the dog, owing to its cosmopolitan distribution and close association with man, is by far the most important source of infestation. This animal becomes infested by eating fertile hydatid cysts in the viscera of animals which can act as intermediate hosts, nearly always the domesticated sheep, ox, or pig. The incidence of the disease in man follows accurately that of the domestic animals of the country.

*Source of
infection*

Man acts as an intermediate host only, occupying the same biological position as the sheep; but, as dogs do not have access to human viscera, such infestation must be regarded as a dead-end as regards completion of the parasitic life-cycle. In the past, in spite of the fact that the ova usually sink in water, great importance has been attached to the contamination of water or fresh vegetables as an aetiological factor, but there is no doubt that contamination of the hands by direct contact, i.e. by handling and caressing dogs, is far more important (Dévé, 1904; Clunies Ross). This explains the relatively high incidence in various occupations, the common occurrence of more than one case in a family, the almost equal incidence in the two sexes, and the common occurrence of infestation during childhood, the age of promiscuity with the dog and of general unhygienic behaviour. Most infestations occur in childhood, although owing to the slow growth of the cyst the disease often does not manifest itself until adult life. Generally a hydatid cyst in man is nearly as old as the host.

*Geographical
distribution*

Although hydatid disease has been recorded in all countries, it occurs most commonly in those countries in which sheep are pastured in large numbers, these animals acting as ideal intermediate hosts. It is thus relatively common in Iceland, Australia, New Zealand, South Africa, Algeria, and South America; smaller foci occur in France, Dalmatia, the Balkans, Italy, and Russia. It is very rare in Egypt and India—in fact in all truly tropical countries—and relatively uncommon in North America, although many sheep are pastured there. It would seem that in the latter country as elsewhere, provided that close association of dog, sheep, and man remains, the incidence of this disease will gradually increase.

Hydatid disease has always been relatively rare in the British Isles, although twenty-three million sheep are pastured and numerous dogs are kept. This is due to the comparatively high standards of public hygiene, the careful regulation of abattoirs and meat inspection, the small number of sheep slaughtered for home consumption, the care taken in feeding dogs, and good water-supplies. There is no doubt that hydatid disease occurs in English sheep, but the *Echinococcus*

granulosus has only rarely been discovered in English dogs. Sporadic human cases occur, as the reports of the various hospitals indicate, regularly but the total number of cases recorded annually is small.

4.—PROPHYLAXIS

As there are two distinct developmental cycles in the life of the parasite, prophylactic measures are easy and should be applied in two ways: (i) by controlling the access of dogs to infected viscera and thus preventing infestation of dogs; and (ii) by educating people about the danger of canine infestation, particularly in respect of children.

5.—PRIMARY CYSTS

(1)—Distribution

In man most of the primary cysts are found in the liver, this organ acting, as it were, as the first filter; but sometimes the parasite passes through the hepatic capillaries and enters the pulmonary circulation, the lungs being the next most common site. The parasites may even pass through the pulmonary capillaries and make their way to any part of the body, and the lessening proportionate incidence as the periphery of the body is reached indicates that carriage by the blood-stream is the only rational explanation of the regional distribution. The following table gives the commonly accepted figures for primary cysts:

DISTRIBUTION OF PRIMARY HYDATID CYSTS (ADULT)

Liver	—	—	—	—	—	76.6 per cent
Lung	—	—	—	—	—	9.4 „
Muscular and subcutaneous tissue	—	—	—	—	—	5.2 „
Kidney	—	—	—	—	—	2.3 „
Spleen	—	—	—	—	—	2.1 „
Bones	—	—	—	—	—	0.9 „
Orbit	—	—	—	—	—	0.7 „
Brain	—	—	—	—	—	0.6 „
Other sites	—	—	—	—	—	2.2 „

Multiple infestations are commoner in the human subject than is usually realized, more than one cyst being present in at least 60 per cent of cases. As the liver is the first filter, any patient who harbours a peripherally placed cyst should be suspected of also having a hepatic cyst. *Multiple cysts*

(2)—Simple Cysts

Simple primary cysts are typically found in children and young adults, *Latency* and their outstanding characteristic is their latency. They may exert pressure on any structure and, as practically any organ may be involved,

Pressure effects

are often responsible for bizarre and protean clinical manifestations. Small cysts in special situations, such as the orbit, the cranial cavity, or the spinal canal, may produce grave symptoms relatively early. Deformity may result, especially in children, but it is remarkable how well large cysts may be tolerated. In fact it may be said that the symptoms of the infestation depend more on environment than on the intrinsic character of the parasite. This is not surprising in the light of the common occurrence of infestation during the growing period, the extremely slow growth of the cyst which enables compensatory changes to occur, and the fact that cysts are shut off from the body fluids of the host by a relatively impermeable adventitia.

*Toleration**Complications***(3)—Rupture of Cyst**

Ultimately, however, complications occur, becoming more common as age advances and the cyst increases in size. They are relatively rare in young subjects and usually appear between 25 and 40 years of age. Practically all complications depend on an escape of fluid from the cyst, this varying from a slight leak, often masked by other symptoms, to a frank rupture (Dew, 1930).

As the cyst enlarges, it may encroach on a natural channel, a hollow viscus, or a serous cavity, one area of the laminated membrane thus becoming relatively unsupported. As a result it gives way spontaneously, even during sleep, after muscular movement, coughing, or straining, or, more commonly, after direct trauma such as a blow, a fall, a crush, or a perforating injury. The tear in the laminated membrane rapidly enlarges owing to its peculiar structure and allows the escape of the contained fluid and hydatid elements. Such rupture takes place commonly into the subcutaneous or muscular tissues, bile ducts, bronchi, alimentary canal, or urinary tract; into a serous cavity, such as the peritoneum, pleura, or pericardium; or into the chambers of the heart or the lumen of large veins.

(4)—Sequelae of Rupture

The sequelae of rupture may be classified thus: (i) general, applicable to practically all types: (*a*) immediate hydatid anaphylaxis (Dévè, 1911); (*b*) delayed—secondary cysts (Dévè, 1901; Dew, 1926); and (ii) special, applicable to cases of rupture into a natural channel: (*a*) immediate—mechanical effects; (*b*) delayed—death of or suppuration in the cyst.

(a) Hydatid Anaphylaxis

Many clinicians have noted peculiar toxic manifestations after puncture or rupture of hydatid cysts. Although these are usually cutaneous, such as urticaria, erythema, and pruritus, many other symptoms may occur, and there is no doubt that these are usually anaphylactic, due to the sudden absorption of specific protein in a sensitized patient. Clinically, whenever vague symptoms arise during

the course of hydatid disease, the question whether or not they are anaphylactic in nature should always be considered. That most patients harbouring a hydatid cyst are specially sensitized is borne out by the high percentage which give a positive intradermal reaction with hydatid fluid.

(b) *Secondary Cysts*

Rupture of a hydatid cyst or puncture by a trocar with evacuation of the specific fluid does not necessarily cause death of the parasite; probably it rarely does so unless followed by infection. The parasitic elements, particularly the scolices, have such powers of persistence that they can survive and ultimately develop into new cysts, often at a distance from the original, this phenomenon being usually described as secondary echinococcosis.

At first clinicians regarded all cases of multiple cysts as due to multiple primary infestations, but they gradually recognized that many were due to secondary cyst formation from implanted scolices (see Fig. 86). Even as late as 1900, however, the view that such highly differentiated structures as scolices could, as it were, revert in their life-cycle ranked with many authorities as



FIG. 86.—Secondary cysts derived from scolices injected with aseptic precautions into peritoneal cavity of a rabbit

a biological heresy, because it seemed contrary to all the laws of the development of the cestodes laid down by van Beneden.

Much experimental work, however, and many correlated clinical and pathological observations have proved conclusively that such a retrogressive metamorphosis is not only possible but relatively common and of great clinical importance. Recognition of this has led to great advances in our understanding of much that was obscure in the pathology and has put the treatment of hydatid disease on a correct basis.

Localized secondary echinococcosis

After rupture of a subcutaneous or muscular cyst a congeries of small secondary cysts, often called seed hydatids, are commonly found in tissue and intermuscular planes. Of a similar nature are those cases of post-operative or post-traumatic recurrence in the region of the original cyst, one type of reactive daughter-cyst formation.

Secondary cysts of the peritoneum and pelvis

These are very common and are due to leakage of scolices from a primary cyst of the liver or, less commonly, of the spleen, kidney, or omentum.

Usually, when the cyst ruptures, hydatid fluid and scolices are shed into the peritoneal cavity with some anaphylactic shock. The scolices may be shed in thousands and are carried by the rush of fluid, by gravity, and by intestinal movement usually to the lower quadrants of the abdomen. They soon become surrounded by lymph and eosinophil leucocytes and rapidly fixed in a secondary site. No doubt many of them are overwhelmed and undergo fibrosis; sometimes the peritoneal reaction around these disintegrating scolices is so extensive that a pseudo-tuberculous appearance is produced. Many, however, survive, become surrounded by a new adventitia, undergo vesiculation, and form secondary cysts. As happens with any other foreign body, the peritoneum gradually spreads over until the secondary cyst gives the impression that it originated outside the peritoneal cavity. Failure to recognize this simple process led many of the older pathologists to believe that these cysts were multiple cysts developed from many hexacanth embryos carried to the sites from the alimentary canal.

Rate of growth

These secondary cysts grow slowly with a latent period of five to twelve years, during which they steadily increase in size, until they in their turn produce symptoms. Owing to the usual rapid recovery the initial rupture is often misinterpreted by the clinician, and its true significance is not recognized until at a later date the discovery of multiple abdominal cysts leads to a retrospective diagnosis. It is thus not uncommon for rupture of a visceral cyst to occur in youth, but for its clinical manifestation and recognition in the form of multiple abdominal cysts to be delayed until adult age. Secondary abdominal cysts are always multiple and often irregular in shape and size, and the relative tenuity of their adventitia makes them further prone to rupture with repetition of the above effects. As a result the peritoneal cavity may become filled with hydatid cysts in all stages of development, a very grave condition aptly described as hydatidosis.

*Hydatidosis**Fate of ruptured primary cyst*

Usually the rent in the primary cyst becomes occluded by adhesions, and the residual germinal elements produce multiple daughter-cysts, one type of localized secondary echinococcosis. It is a general rule that, when multiple simple peritoneal cysts are found, there is also a primary visceral, nearly always hepatic, cyst containing daughter-cysts. Somewhat similar phenomena may occur after rupture of a cyst into the pleura or pericardium. Sometimes coexistent communication with a bile duct causes intraperitoneal rupture of a hepatic cyst, giving rise to leakage of bile into the peritoneal cavity with the production of a choleperitoneum, often a puzzling condition.

Metastatic secondary echinococcosis

This condition, the rarest but most interesting type of all secondary



Multiple metastatic hydatid cysts of the brain, secondary to an intraventricular rupture of a left-sided cardiac cyst two years previously

PLATE V

cysts, is due to a rupture of a fertile simple cyst into either the heart or the venous system. The rupture may take place on the venous side of the circulation into peripheral veins or into the right cardiac chamber, or on the arterial side into one of the left cardiac chambers. Two sets of sequelae are possible. In both of them grave anaphylactic symptoms may occur, although recovery from these takes place as a rule.

If the cyst ruptures into the venous side of the circulation, the scolices are carried through the right ventricle into the lungs, where they are filtered out and ultimately give rise to secondary pulmonary cysts. These cysts are characterized by their multiplicity, their bilateral and peripheral distribution, and their uniform size. *Venous metastases*

When a cyst ruptures into the left auricle or ventricle, the hydatid elements enter the systemic circulation and give rise to metastatic cysts in various parts of the body. Owing to the relative size of the carotid arteries and their place of origin from the aortic arch, most of the scolices are carried to the brain, which becomes the seat of 60 to 70 per cent of these secondary cysts (see Plate V). Some scolices, however, may escape to the kidney, spleen, or liver. All these are simple cysts of approximately the same size, rarely becoming larger than a hen's egg. *Arterial metastases*

These examples illustrate the classical manifestations of secondary echinococcosis, which is now clearly established as regards its aetiology, pathology, and clinical aspects. It is a general rule, in the case of multiple cysts, that, if the extrahepatic cysts are more than one-third of the total, it is probable that they are secondary cysts.

(c) Mechanical Effects

The mechanical effects of rupture of a cyst are seen in cases of rupture into a natural channel. After the initial flooding, which is rarely serious, the passage of hydatid products along the channel leads to attacks of colic or intermittent, partial, or complete obstruction. These are immediate effects, although they may continue for months as fractional evacuation of the cyst contents occurs.

(d) Suppuration

Occasionally the parasite dies; if conditions remain aseptic, inspissation and encapsulation by fibrosis and calcification take place. Micro-organisms do not find their way through the intact laminated membrane, and in the case of simple cysts some degree of rupture of this membrane is an essential preliminary to suppuration. Once the hydatid membrane collapses, however, the serum exuded into the cavity makes with the hydatid debris such an excellent pabulum for the growth of micro-organisms that, when open contact with a lining epithelium is made, infection soon occurs. Small ducts, however, may open into the cavity, and yet it may remain aseptic for years; occasionally, too, actual repair of the opening may occur. The time that elapses between rupture and infection depends on many factors, so that, although infection may coincide with the rupture, it is often delayed for weeks or months. *Repair*

(5)—Diagnosis of Rupture

Microscopical examination for hydatid products, such as scolices, hooklets, or laminated membrane, should always be carried out in all cases in which material is expectorated, found in the faeces, or procured by exploratory puncture. These products are extremely resistant to putrefaction and can often be recognized long after death of the parasite.

X-rays

Radiography has revolutionized the diagnosis of all intrathoracic cysts, because the saline cystic contents are relatively opaque and give a characteristic rounded shadow. In subdiaphragmatic cysts distortion or elevation of the diaphragm is often a striking feature. Calcareous changes in the adventitia are also often noted in old cysts in any situation. The correct interpretation of the protean radiological manifestations often presents difficult problems and requires much experience. X-ray examination alone, however helpful it can be, often fails in young subjects with cysts of moderate size and in cysts which have ruptured; recourse must then be made to various immunological tests. The precipitin test, as first used by Fleig and Lisbonne, has proved of limited value and has given way to the complement-fixation test as modified by N. H. Fairley, using fresh hydatid fluid from sterile sheep cysts as antigen. I have found Casoni's intradermal test, using sterile hydatid fluid from the sheep, of inestimable value, particularly in uncomplicated cysts. By a combination of the above methods 90 per cent at least of all cysts can now be confidently diagnosed (Casoni; N. H. Fairley; K. Fairley, 1923; Dew, Kellaway, and Williams).

Complement-fixation test

Casoni's test

6.—HYDATID DISEASE OF THE LIVER

693.] As in all other sites, two groups of cases must be recognized, the clinically uncomplicated and the complicated forms.

(1)—Simple Hepatic Cyst

(a) Clinical Picture

This is typical of the disease in young subjects, the outstanding clinical aspect being its latency, so that, as symptoms may be entirely lacking, the condition is often found by accident during routine examination. If the cyst happens to be in the upper part of the liver, it will often not be recognized until the patient is relatively old. Tumour formation in the upper abdomen or some bulging of the costal margin is often noted. The tumour is characteristically rounded, smooth, very tense, and non-adherent. Pressure effects are rare, even with large cysts, and it is surprising how large a cyst may be tolerated, the patient's general condition remaining excellent. The diagnosis must be made from other cystic swellings of this region, and in this respect Casoni's intradermal test is of great value, particularly as in this type the complement-fixation test is often negative.

Daughter-cysts are present in most of the hepatic cysts of the adult; although these cysts may appear as clinically uncomplicated, it is probable that all are really pathologically complicated and that some leakage has occurred at a previous date. This is borne out by the fact that the great majority of these cysts show some degree of contamination with bile. In fact in some cases a history of vague attacks of hepatic pain and some anaphylactic symptoms can be elicited. These cysts, too, are comparatively latent but may be associated with various vague symptoms which direct attention to the liver. *Daughter-cysts*

Pain is rare, and when it is severe the condition must be regarded as probably due to leakage into the biliary passages with the passage of small quantities of debris down the ducts. Discomfort is sometimes present as a sensation of weight or distension in the hypochondrium. *Pain*

Gastric disturbances are very common; most patients with large hepatic cysts complain of attacks of nausea, distension, and, occasionally, attacks of vomiting. So-called indigestion may be the only symptom complained of. Other pressure effects are rare and depend on the size and the situation of the cyst. In subdiaphragmatic cysts, which owing to their sheltered position are notoriously latent, pressure on the diaphragm may induce some degree of dyspnoea, or pressure on the inferior vena cava, or some enlargement of the collateral venous drainage. It is surprising how seldom cysts of the inferior surface of the liver produce pressure effects of any consequence. Jaundice is rare in uncomplicated cysts, except those which actually involve the porta hepatis (transverse fissure). *Gastric symptoms*
Other pressure symptoms

Owing to the preponderance (75 per cent) of cysts of the inferior surface of the liver, a visible or palpable rounded cystic tumour is often discovered at once. Extension of such cysts on the left side takes place usually in front of the stomach and colon, whereas on the right side it is often retrocolic or retrogastric and closely simulates a renal tumour. The swelling is continuous with the liver, moves with respiration, and is dull on percussion. Hydatid fremitus, although often quoted, is relatively rare and depends on the presence of daughter-cysts with definite degrees of tension within the adventitia. In cysts of the upper quadrant there may be very great increase of hepatic dullness upwards, as these cysts are often not recognized until they are very large. They may be so large as to extend to the level of the third rib. *Physical signs*

(b) Differential Diagnosis

In antero-inferior cysts of the liver such conditions as splenic enlargement, hydronephrosis, pancreatic cyst, mucocele of the gall-bladder, and various causes of hepatomegaly must be differentiated, for which purpose the immunological tests are extremely valuable. *Antero-inferior cysts*

In cysts of the superior surface of the liver pleural effusion and hydatid of the right pulmonary base particularly must be differentiated. A useful sign is that given by examining the lungs with the patient on the hands and knees; in subdiaphragmatic cysts there is an increase *Superior cysts*

in the area aerated and in the area of resonance, owing to the cyst falling away from the diaphragm and allowing greater pulmonary excursion. There is not any change if either of the other two conditions is present. Radiography may be of the greatest value, as distortion, fixation, or elevation of the diaphragm is commonly found in the one and intrathoracic opacity in the other. Calcareous change in the adventitia in this situation is often seen in old cysts and gives a characteristic radiograph.

(c) *Treatment*

As the tendency for complications to occur increases as these cysts enlarge, operation should be advised in all cases except those in which, owing to the degree of calcification present, the cysts are judged to be dead or quiescent. Operative interference in this type of case is often followed by persistent sinus formation due to the introduction of quiet infections, the thick calcareous wall then separating so slowly that a sinus may persist for many years.

*Persistent
sinus*

Because (i) radiotherapy has been found to have no effect on the parasite, (ii) the small fluid exchange between the parasite and the host renders intravenous therapy hopeless, and (iii) death of the cyst in situ by no means relieves the patient of the danger of infective complications, treatment consists in free surgical exposure by the most direct route, care being taken in the case of superiorly placed cysts to avoid the pleura, if possible, by making the incision well anteriorly or, failing that, to perform the operation in two stages, as pleural contamination is a very real danger.

Formalin

If the cyst is simple and clean, it should be formalinized before being opened to kill the scolices, which, if any are left in the field of operation, must always be regarded as a potential source of secondary cysts. The contents should next be evacuated by a pump and the laminated membrane removed. The parasite is not adherent to the inner wall of the adventitia, so that in the case of simple cysts the collapse of the cyst after opening causes it to separate, and it can then be easily coaxed out by means of a couple of pairs of ovum forceps. In the case of multilocular cysts an ordinary table-spoon aided by a wide-bore pump is very useful in scooping out the daughter-cysts and debris. The adventitia is then filled with normal saline and sutured, the wound being closed without drainage. In most cases, however, in adults at least, the cyst contains daughter-cysts and may contain some bile-stained fluid or debris. These cysts can often be treated in the same manner, although formalinization before opening is not so useful, as it cannot affect the scolices within the daughter-cysts. It should, however, be used to prevent contamination of the wound. If the cyst appears clean and sterile, it should be filled with saline and sutured.

Drainage

Drainage is not necessary in many cases; if there is any uncertainty in the mind of the surgeon, he should leave one suture long as a guide to the post-operative puncture which may be needed, or put a tube

down to the suture line. In any case in which suspicion as to the sterility is aroused a drain should be placed in the cyst.

(2)—Complicated Hepatic Cyst

Complications of the cysts are practically always associated with some degree of leakage or rupture. This causes, as a rule, dramatic alteration of the clinical picture, and in approximately 70 per cent of cases this is why patients seek advice. The complications which may happen to a hepatic cyst are very numerous and in order of importance are: (a) intrabiliary rupture; (b) suppuration; (c) intraperitoneal rupture; (d) intrathoracic rupture; and (e) other forms of rupture.

(a) Intrabiliary Rupture

There seems to be little doubt that in the adult this is the commonest complication of hepatic cysts, varying from a small leakage with some biliary contamination of the cyst contents to frank rupture into the larger ducts with the passage of hydatid debris down the duct and a close simulation of biliary colic. The rupture usually takes place into the larger intra-hepatic ducts; Fig. 87 shows the relative frequency of the various sites.

The cyst nearly always contains daughter-cysts and debris, which may be forced into the ducts and so enter the duo-

denum. Owing to its resistant nature the laminated membrane can often be recovered by washing the stools. Various degrees of obstructive jaundice and infective cholangitis must occur in many of these cases.

Clinically, this type of rupture is rare before the age of twenty, reaching its peak incidence between thirty-five and forty-five. The actual rupture is often spontaneous but may occur after trauma or muscular effort, and the pain and symptoms so produced may be the first sign of hydatid disease. Very often, however, there are premonitory symptoms of hepatic pain and intermittent jaundice, sometimes with anaphylactic symptoms, which may at first be rather misleading. The first symptom is usually severe biliary colic, which may recur over a period of years. In some cases actual fractional evacuation of the contents of the cyst with ultimate natural cure may occur. Various anaphylactic symptoms, especially urticaria and pruritus, are common.

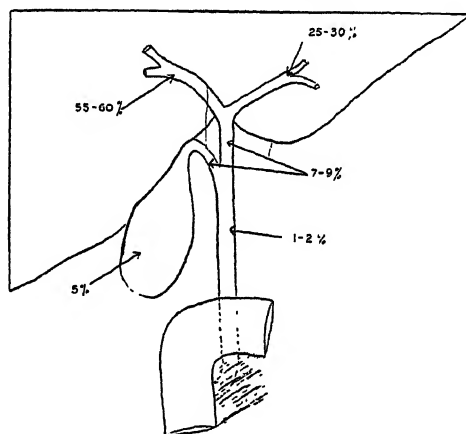


FIG. 87.—Diagram of sites of intrabiliary rupture of hepatic cysts

*Premonitory
symptoms*

Jaundice

Jaundice is a constant symptom and varies from mild transient attacks to true obstructive jaundice. The common occurrence of jaundice in hepatic hydatid disease can hardly be over-emphasized. Fever may be entirely absent for months, but with the almost inevitable onset of infective processes in all cases in which the leakage continues intermittent fever with rigors appears.

Differential diagnosis

These cases simulate cholelithiasis very closely, and this is the commonest error of diagnosis even in Australia. Hydatid disease involving the ducts tends to occur at a somewhat earlier age than stone in the common duct and, unlike gall-stones, affects males a little more often than females (occupational aetiology); gall-stones often give a fairly long history, whereas hydatid disease is often dramatic in its onset, and the pain produced by the soft slippery hydatid membrane is not so severe as that of gall-stones. Hepatomegaly is the rule in hydatid disease, and examination of the stools under a tap of running water will often reveal hydatid debris. Radiography and the immunological reactions are invaluable aids to the diagnosis of these cases.

Course and treatment

In untreated cases the symptoms may continue for many years (up to twenty-seven in one case), while fractional evacuation of the cyst takes place, but the patient continually runs the risk of infective cholangitis with its serious if not fatal consequences.

As soon as the diagnosis is made, operation should be advised. This consists in evacuation and drainage of the cyst with or without (depending on the degree of block and infection) drainage of the common bile duct. There are many interesting surgical problems associated with the management of these cases, for a consideration of which special articles should be consulted (Finocchietto; Carroddus).

(b) Suppuration

This is caused by the introduction of organisms, practically always from the biliary passages, into the cyst. This can only occur after some degree of intrabiliary rupture and is a common sequel of any such rupture. The organisms vary greatly, but in at least 20 per cent of cases anaerobic bacilli are present. The cavity becomes filled with pus, the adventitia as a rule is converted into a pyogenic membrane, and the surrounding hepatic tissue often shows signs of hepatitis.

Clinical picture

Clinically these cases show all the symptoms and signs of intrahepatic suppuration. As a safety-valve effect may be present, the tension and the degree of toxæmia produced vary greatly. Although as a rule the latter is severe, a large infected cyst of low tension is sometimes comparatively well tolerated. In some cases the cavity contains gas, and so a hepatic pneumocyst is produced which gives varied signs on percussion or radiography.

Differential diagnosis

In those cases in which frank intrabiliary rupture has taken place with classical signs and symptoms the diagnosis is readily made. In other cases, however, there may be great difficulty in determining whether the infective process is intrahepatic or extrahepatic and whether

it is hydatid in nature or not. As a rule, however, the use of a combination of the diagnostic procedures indicated above leads to a correct diagnosis.

The cysts should be freely drained without delay, care being taken to avoid contamination of either pleura or peritoneum. The contents, often very foul and highly infected, are a great source of anxiety to the surgeon from this point of view. The sudden introduction of aerobic conditions with the open drainage not infrequently allows latent streptococci to multiply and produce a complete alteration of the bacterial flora, often with fulminating toxæmia.

Treatment

(c) *Intraperitoneal Rupture*

This complication is relatively frequent and is the commonest complication seen in young subjects owing to the tenuity of the cyst wall at this age. It may be produced by injury of any sort or may occur spontaneously. The spilling of hydatid fluid and elements, usually in the form of scolices or small daughter-cysts, gives rise to a series of immediate and delayed phenomena, some of which have already been mentioned. They mainly depend on the condition of the cyst and are best summarized in the following table:

POSSIBLE EFFECTS OF INTRAPERITONEAL RUPTURE OF HEPATIC CYST

TYPE OF RUPTURE	IMMEDIATE EFFECTS	EFFECT ON ORIGINAL CYST	LATE PERITONEAL EFFECTS
Univesicular cyst with extrusion of intact cyst (very rare).	Often none noted.	Scar formation at site in liver. Biliary leak very rare.	Single omental or pelvic cyst in new site. Choleperitoneum practically unknown.
Univesicular cyst with rupture of laminated membrane (common in young subjects).	Anaphylactic and peritoneal shock.	Reactive daughter-cyst formation usual, with closure of rent; biliary leakage rare; suppuration rare. Sometimes the whole mother-cyst is extruded, and a scar is formed in the original site.	Multiple secondary cysts of the abdominal cavity almost invariable; pseudotuberculous thickening of the peritoneum rare. Choleperitoneum or peritonitis also rare.
Multivesicular cyst without biliary contamination or connexion.	Anaphylactic and peritoneal shock.	Recurrence from residual daughter-cysts; scar formation if all extruded; primary or secondary biliary leakage at times; sometimes suppuration occurs.	Secondary cysts from daughter-cyst implants. Choleperitoneum sometimes occurs as delayed effect. After some delay suppuration may also occur.
Multivesicular cyst with biliary contamination or connexion.	Anaphylactic and peritoneal shock. Choleperitoneum.	Biliary fistula into peritoneum; secondary suppuration sometimes.	Choleperitoneum usual, suppuration common; secondary sowing of cysts can occur sometimes, even in spite of bile.

Clinical picture

After the rupture a previously noted swelling may disappear. As a rule the patient experiences severe upper abdominal pain with shock and meteorism. Anaphylactic symptoms are very common, and the common occurrence of urticaria and pruritus often leads to the diagnosis of gastro-enteritis.

After a few days in most cases the patient appears to have completely recovered. Many such cases in children have been misinterpreted both by practitioners and by parents, being regarded as food poisoning, abdominal colic, or gastro-enteritis.

In simple cases without biliary contamination or infection secondary daughter-cysts develop in the abdominal cavity and do not become clinically manifest until after the lapse of five to fifteen years, when they are large enough to produce multiple palpable tumours. Sometimes the rather puzzling abdominal crisis of the past is then remembered and a correct retrospective diagnosis made.

Chole-peritoneum

In other cases the hepatic cyst may communicate with a bile duct, and the contents may as a result be grossly bile-stained or even infected. Infection is rare, but infective peritonitis has been observed. In the former event a hydatid choleperitoneum may result; this is a very interesting condition, and it is often only the detection of bile-stained ascitic fluid that leads to a diagnosis (Dévé, 1907).

Treatment

These cases, if diagnosed, should usually be explored surgically. As complete an abdominal toilet as possible should be carried out, drainage as a rule not being required. The patient should be warned of the probable development of secondary cysts some years later.

(d) Intrathoracic Rupture

This is relatively rare, but is well known in all countries in which hydatid disease is common (Dévé, 1907). Rupture usually takes place from a large right subdiaphragmatic hepatic cyst through the right cupola into the pleura and may produce a cholethorax or a cholepyothorax, or into a bronchus by way of previously formed adhesions and pulmonary consolidation. There are many anatomical types possible and as a result many different pathological pictures, such as a combination of intrathoracic and intrabiliary rupture, in which case there may be profuse biliary expectoration.

Clinical picture

There may be prodromal signs, such as pleurisy or low-grade pneumonia, before the actual rupture takes place, but very often the first sign is the onset of severe tearing pain in the chest, often with the expectoration of blood-stained saline fluid, pus, blood, or bile. The contents of these cysts are often infected and very foetid, and owing to the presence of numerous daughter-cysts fractional evacuation takes place through the bronchus over a long period, unlike the cases of intrabronchial rupture of a pulmonary cyst, which being large and simple often causes one very voluminous expectoration. The appearance of bile in the sputum is diagnostic of a hepatic communication, and in some distressing cases practically all the patient's bile may be side-

tracked through a bronchus. So long as any hydatid material persists, the patient as a rule notices a fishy taste in the sputum. Radiography sometimes reveals a characteristic appearance.

In those cases in which intrapleural rupture takes place, after the initial pain and shock the patient usually presents the picture of empyema thoracis, and the discovery of bile-stained pus in the aspirating syringe often comes as a complete surprise. Treatment of these cases may be very difficult; unless the surgeon is aware of the vagaries of hydatid pathology, mistakes are easy. If the hepatic cyst can be adequately drained at a dependent spot and any complicating empyema thus be controlled, the patient usually makes good progress.

Treatment

(e) Other Sites of Rupture

These are rare, but ruptures of hydatid cysts into the stomach, intestinal tract, pelvis of the kidney, urinary bladder, and venous system are all well known.

7.—CYSTS OF THE PERITONEUM AND PELVIS

(1)—Aetiology

694.] Primary cysts in this region are rare but do occur as simple cysts in any situation. As a rule cysts here are multiple and are really secondary cysts derived from a previous intraperitoneal rupture of a hepatic cyst as above described. More rarely a primary splenic, renal, or omental cyst is the source. As a general rule all multiple cysts of these cavities are secondary cysts, and in such cases a cyst containing daughter-cysts should be suspected in the liver.

(2)—Clinical Picture

There is often a history of a previous operation on a cyst in the upper abdomen, in which event the secondary cysts are due to spilt scolices, or of some injury, or of some peculiar and often misunderstood attack of upper abdominal pain. All of these will be dated back five to fifteen years by the patient, who at the time he presents himself will complain of gradual enlargement of the abdomen or possibly of the presence of one or more lumps.

History

On examination these patients present rounded cystic swellings in the abdomen, these being freely movable and neither tender nor painful. In advanced cases the whole peritoneal cavity may be packed with cysts, a condition known as hydatidosis. These are due to secondary and tertiary rupture of the secondary cysts with fresh sowing of scolices, and as a result the cysts may be of very different sizes. These patients often complain of repeated anaphylactic attacks, which apparently correspond to the repeated ruptures.

Cysts of the pelvis often occupy the rectovesical or the recto-uterine pouch (pouch of Douglas), where they produce symptoms of pressure

Pelvic cysts

and cause deformity of the bladder, rectum, or uterus. As a result there are several clinical pictures. The commonest clinical discovery on vaginal or rectal examination is an elastic cystic tumour, which may be mistaken for an ovarian cyst in the female or a greatly enlarged prostate in the male. In other cases symptoms of disordered pelvic function are produced by pressure effects.

(3)—Treatment

The only treatment is repeated surgical operation with formalinization and evacuation of the cysts. Although the toleration of the patient for these often innumerable cysts is surprising, although they rarely cause much interference with the functions of abdominal viscera, and although multiple operations sometimes cure, the prognosis is very grave.

Prognosis

8.—PULMONARY CYSTS

695.] Primary pulmonary cysts comprise about 10 per cent of all cysts in the adult, but it is probable that, as many patients undergo spontaneous natural cure, this figure is an underestimate. The right lung is affected more often than the left in the proportion of 65 to 35, and multiple infestation is commoner than is usually recognized. The cyst grows relatively rapidly in this situation owing to the vascular non-resistant tissue, and, although rupture into a bronchus is the usual termination, sometimes very large intact cysts occupying the greater part of the chest cavity are seen, even in young subjects. These cysts are fertile single cysts as a rule, daughter-cyst formation being very rare.

(1)—Simple Pulmonary Cysts

Clinically these are strangely latent, although patients harbouring a cyst of quite ordinary size (4 inches diameter) often show delayed resolution of ordinary respiratory infections (K. Fairley, 1922). A dry cough is common, but pain or dyspnoea even in the case of relatively large cysts is rare. Haemoptysis is very common, being present as an early or initial symptom in 60 per cent of uncomplicated cases; it is only severe, however, when associated with actual intrabronchial rupture. Examination reveals all the signs of an intrapulmonary tumour, depending on the size and the site of the cyst.

Clinical picture

Diagnosis

The association of cough with haemoptysis in a relatively young adult leads to the suspicion of pulmonary tuberculosis. Radiography, however, gives a characteristic picture owing to the opacity of the saline contents of an unruptured cyst and has revolutionized the diagnosis of this condition. A rare source of error is neoplasm of the lung; when cysts are near the hilum, the diagnosis must be made from mediastinal tumour and from Hodgkin's disease. The Casoni intradermal test is very valuable, being positive in about 86 per cent of cases, but the complement-fixation test is often negative owing, no doubt, to the small amount of specific antigen that has been absorbed.

If the cysts are small and deeply placed, they should be left alone because of the difficulties, mainly of a technical nature, attending surgical interference and because at least 75 per cent of them undergo natural cure by intrabronchial rupture and fractional evacuation. Subpleural and larger cysts should be operated upon by a one- or two-stage procedure and evacuated. As the use of formalin is contra-indicated here, the greatest care must be taken to prevent contamination of the field by scolices. *Treatment*

(2)—Complicated Pulmonary Cysts

(a) Intrabronchial Rupture

The common end of all pulmonary cysts of any size is involvement of and rupture into a patent bronchus. This may cause a mild leakage which may not be recognized or a frank rupture with the discharge of much saline fluid, blood, and membrane into the respiratory passages.

The patient, often an apparently healthy adult, suddenly feels something go in his chest and experiences a sudden pain. This is followed by paroxysmal coughing and a rush of blood-stained salty fluid into the mouth and nose. Hydatid membrane is often present but may be masked by the blood and mucus. Haemoptysis is common and occasionally alarming. As a rule there is anaphylactic shock due to the absorption of hydatid fluid. The patient rarely dies as a result of the primary rupture but suffers for some days from paroxysmal cough with intermittent expectoration of blood or membrane. Very often the symptoms then abate, but sooner or later they recur in a milder form. These patients, however, may sometimes show surprisingly few symptoms for long periods. On examination there are all the signs of a pulmonary cavity, the physical signs varying with its degree of evacuation and the size of the bronchial communication. When, as often happens, the opening becomes blocked and reactionary fluid and air accumulate in the cavity, forming a hydatid pneumocyst, peculiar and puzzling signs on auscultation or percussion may appear. *Clinical picture*

Natural cure of intrabronchial rupture is not uncommon and depends on such factors as the following. The size of the cyst is important, as on it will depend the thickness of the adventitia and therefore the possibility of complete collapse and the time taken for disintegration and expectoration. Small cysts, and therefore cysts in children, may be expected to undergo such a cure more readily. The size of the bronchial communication and its position in respect of the cavity are also important. The larger the bronchial opening and the more dependent its position, the better are the chances of evacuation. The site of the cyst is also important. Apical cysts are more likely to involve the bronchi while they are yet small, and the opening thereinto will probably be inferior to the cyst cavity and so will facilitate drainage. Deeply placed parabronchial cysts will also fulfil most of the conditions. All authorities agree that the prospect of natural cure in this type of cyst is very good, up to 75 per cent at least. These cysts, however, rarely *Course and prognosis*

come for diagnosis before rupture has taken place, but the routine use of X-rays will lead to their recognition more often in the future. After rupture a careful history should be taken about the amount of fluid and membrane expectorated, an accurate stereoscopic radiograph taken to ascertain the size and site of the cavity, and the prognosis based on this. Subpleural cysts are often large before they rupture into a bronchus, and the opening is often not inferior. Pleural adhesions are often present



FIG. 88.- Radiograph of pulmonary pneumocyst due to intrabronchial rupture of simple hydatid cyst in a man aged 26

and, combined with the presence of the somewhat thick adventitia, may preclude complete collapse, so that thorough evacuation and natural cure are rare. Infection, too, is more likely to occur. The older observers saw many cases of this type and on them based their rather gloomy prognosis.

*Differential
diagnosis*

This condition closely simulates pulmonary tuberculosis, particularly if the early history of the rupture is incomplete or inaccurate. If the cavity is completely evacuated of fluid and contains only crumpled membrane, there may be very few physical signs, and even a good radiograph may give little information. Careful examination of the sputum for tubercle bacilli and hydatid products should be carried out; the fishy taste of the sputum, mentioned on page 555, may persist so long as any hydatid membrane remains in the cavity. If the collapsed adventitia is relatively thick, good and characteristic radiographs may be

obtained, and in all cases of pneumocyst the picture is almost diagnostic (see Fig. 88).

These cases should be treated expectantly; surgical interference, however, is indicated if a pneumocyst is produced or if symptoms of infection supervene. *Treatment*

(b) *Suppuration*

This is a common sequel of intrabronchial rupture and occurs when the bronchial opening is neither inferior nor large enough to allow of free evacuation. The clinical picture then changes to one of pulmonary abscess, although the degree of toxæmia differs according to the tension inside the infected cavity. There is the usual risk of extension to the pleura or throughout the lung. Foul expectoration, recurrent hæmoptysis, cough, and pyrexia are the outstanding clinical features. *Clinical picture*

In these cases the cavity must be treated like an abscess and drained. Technical difficulties, mainly in respect of the pleural cavity, are present but can be overcome if adhesions are present or, in their absence, by a two-stage procedure. *Treatment*

(c) *Intrapleural Rupture*

This is rare and, although it may occasionally lead to secondary echinococcosis of the pleural cavity from sowing of scolices under sterile conditions, it usually, owing to the coincident presence of a bronchial communication, produces a hydatid pneumothorax, which in turn may become a pyopneumothorax (Dévè, 1925; Barnett).

As a rule severe spontaneous pain in the chest with shock and anaphylactic symptoms is the outstanding feature. Dyspnoea and cyanosis are sometimes extreme, and examination of the chest reveals typical pneumothorax, which is rarely of the valvular type. After the initial symptoms the patient usually rapidly improves. *Clinical picture*

The condition may remain non-infected and the patient may develop secondary cysts of the pleura, but, as a rule, infection of the fluid in the pleura takes place. The condition is usually mistaken for tuberculous pneumothorax, although this, unlike hydatid disease, is rare before the age of sixteen, is commoner on the left side than on the right, and may be associated with a suggestive history, and *Mycobacterium tuberculosis* may be found in the sputum and signs in the opposite lung. Radiography may give information of positive value in both conditions. Removal and examination of some of the pleural fluid, which is always present after a day or two, may reveal hydatid hooklets or a cellular exudate composed almost entirely of eosinophil cells. The immunological tests for hydatid disease are invariably positive in the presence of this disease. *Differential diagnosis*

Most of these cases should be subjected to thoracotomy and the condition found dealt with, a complete toilet of the pleural cavity being carried out. *Treatment*

9.—CYSTS OF THE BRAIN

(1) Primary

Incidence

696.] Primary cysts of the brain are due to blood borne hexacanth embryos. Owing to the relative size of the carotid arteries in children the brain is the most commonly affected site (4.9 per cent) after the lungs. This is the true incidence of primary cysts and, as few of these patients reach adult life, at any rate with the cyst intact, infection of the brain in the adult is only 0.7 per cent. On the other hand, secondary cysts, which are metastatic and multiple, are practically confined to the adult (Dew, 1934).

These primary cysts usually occur in the cerebrum; they grow relatively rapidly and, although they may reach a very large size, remain univesicular. Like other cerebral tumours they produce various local and general symptoms, and their localization calls for the use of all the usual modern methods of diagnosis (see Plate VI). (See CYSTICERCOSIS, Vol. III, p. 531.)

Cerebral cysts should be treated by craniotomy and evacuation without drainage.

(2)—Secondary

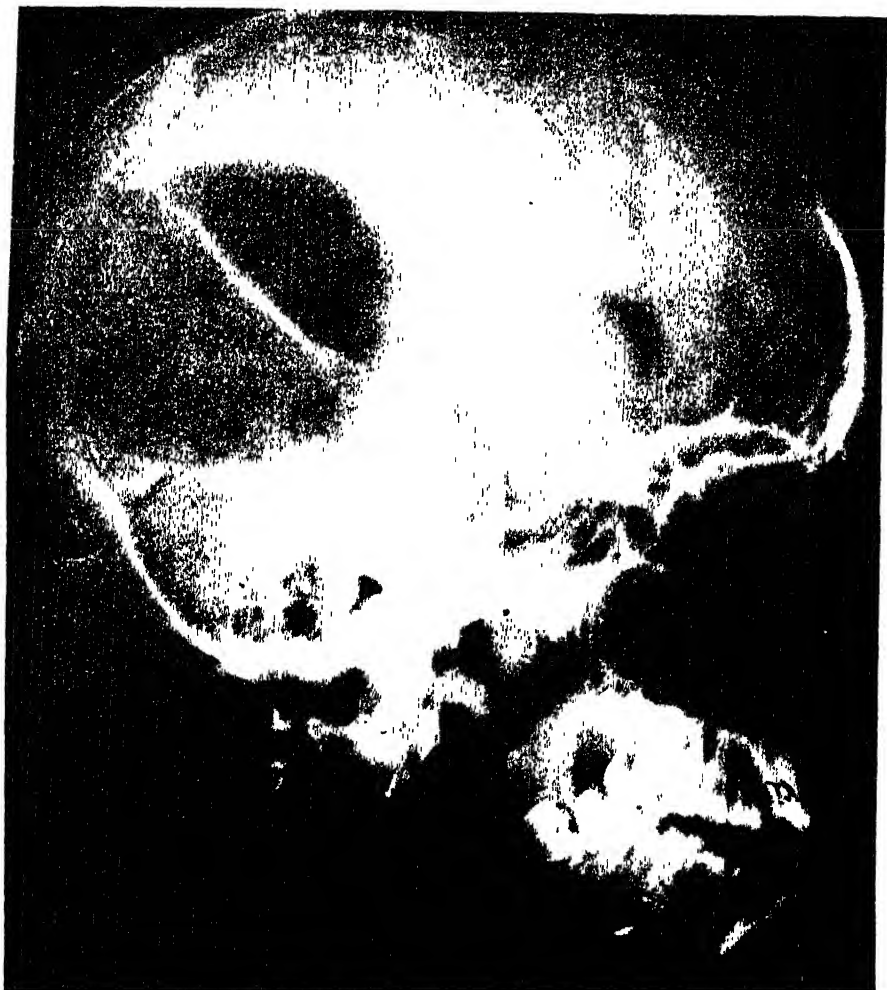
These are always due to left-sided intracardiac rupture of a simple fertile cardiac cyst, the scolices being carried as minute emboli to the brain, in which after two to four years they produce multiple cysts. Death is usually due to increase of intracranial pressure with a protean symptomatology due to the multiple lesions, but sometimes before this occurs a second intracardiac rupture takes place with fatal embolism of the middle cerebral artery from the small daughter-cysts then present in the original cyst.

10.—CYSTS OF THE SPLEEN

697.] These are well known and are very often associated with a hepatic cyst. A splenic cyst produces a tumour in the splenic region, and clinically the cyst may either pass into the abdomen, where it simulates other cystic swellings of this region, or elevate the diaphragm, in which event it may remain latent for years. Complications, of which the most frequent is leakage into the peritoneal cavity, are relatively rare (Mills).

11.—CYSTS OF THE KIDNEY

698.] Cysts of the kidney, if uncomplicated, cause the symptoms and signs of a renal tumour. The common end, however, is rupture into the renal pelvis with the passage of debris down the ureter, the condition closely simulating renal colic. Hydatid material may be found in the



Radiograph of skull of boy aged 13 showing air in a univesicular hydatid cyst of the occipital lobe of the brain. There were evidences of intracranial tumour, but localizing signs were absent, and bilateral ventricular puncture was attempted. The right ventricle was entered at 4.5 cm. and seemed to be displaced laterally. The left needle struck fluid under high pressure at 2 cm. Air was introduced into each needle, and the radiograph showed that the left needle had entered a large cyst. The crumpled laminated membrane can be seen stretching across the cyst. The fluid was found to have a high saline content, but no hooklets were found. Operation disclosed a typical simple cyst, which was removed. The patient made a complete recovery

PLATE VI

urine, and fractional evacuation may go on for many years, although infective processes often intervene with modification of the clinical picture. Nephrectomy is usually indicated sooner or later (Craig).

12.—CYSTS OF THE BONES

699.] In this situation the hydatid process assumes a peculiar diverticulate form owing to the resistant nature of bony tissue. The parasite grows extremely slowly along the bone canals, and semi-solid hyaline masses with little tendency to form fluid are produced. When, however, the disease invades the soft tissues, typical cystic para-osseous swellings are produced. The bones most commonly affected are the femur, ilium, spine, tibia, and humerus. Clinically it is manifested by a relatively painless spontaneous fracture, an extra-osseous cystic swelling which simulates cold abscess very closely, or, in the case of the spine, pressure effects on the spinal cord. Treatment is entirely surgical and is unsatisfactory because of the difficulty of delimiting the diseased area. In hydatid of the spine with compression paraplegia the decompressive effect of laminectomy may be of temporary value.

13.—MISCELLANEOUS CYSTS

700.] Hydatid cysts have been reported in practically all organs and in all sites. Small cysts may in some situations, such as the orbit, spinal canal, and heart, produce symptoms while yet small, but in the main they are strangely latent, simply producing a slowly progressive cystic swelling. In all such cases the diagnosis may be in doubt, but the immunological tests have a distinct value.

14.—*ECHINOCOCCUS ALVEOLARIS*

(1)—Historical

701.] In 1855 Virchow first pointed out the echinococcal nature of a peculiar disease of the liver which was relatively common in Tyrol and neighbouring regions and had for long been regarded as a variety of colloid cancer. Since that time two schools of thought have existed as to the nature and aetiology of this peculiar variety of hydatid disease. The monists, represented by Virchow and several European pathologists, believed that it was an example of parasitic variation and that there was only one taenia; the dualists, represented by Posselt, Mangold, and some other pathologists, Austrian and French, maintained that there were two distinct parasites. The dualists' main argument was based on the fact that the disease apparently had a very narrow geographical distribution, mainly in central Europe, and that it was unknown in the

classical hydatid countries, Iceland, Australia, and South America. The monists could not answer this satisfactorily, but countered with the argument that, if there were two distinct parasites, one confined to man, the parasitic life cycle could not be completed, as dogs did not have access to human livers. A controversy which constitutes one of the most interesting in pathology has been carried on for nearly seventy years, and in spite of a good deal of inconclusive animal experimentation complete unanimity has not been reached. Dévé, the French authority, for many years leaned towards the side of the dualists, but the discovery of more and more cases outside the alleged narrow geographical distribution and the reports of transitional types have at last persuaded



FIG. 89.—*Echinococcus alveolaris* in liver (first reported Australian case)

him of the soundness of the monist doctrine. I recorded the first case in Australia and have for some time championed this monist cause, but Posselt has not yet been persuaded. (Dévé, 1912, 1934; Dew, 1931; Posselt.)

(2)—Morbidity Anatomy

The disease usually affects the liver and is characterized by the presence of innumerable small irregular cavities containing crumpled and discoloured hyaline material, all enclosed in a dense non-

vascular adventitious tissue, which often shows some calcification. These cavities rarely exceed one centimetre in diameter, there is as a rule little hydatid fluid in them, scolices are often absent, and the lesion after fixation looks rather like a sponge. There is no trace of peripheral encapsulation, the outline is irregular and indefinite, and the lesion insidiously invades all the surrounding tissues. As a rule there are central necrosis and cavitation of the central portion, the resultant brownish or bile-stained fluid containing broken down hyaline material and debris. This picture is so unlike ordinary hydatid disease that it is not surprising that its true nature was overlooked (see Fig. 89).

(3)—Clinical Picture

The disease is often found at operation or at necropsy, but accurate diagnosis is sometimes made in those countries in which it is relatively common. The hepatic type is the commonest, the earliest manifestation consisting of digestive disturbances, anorexia, and hepatic discomfort, followed by the insidious onset and persistence of jaundice. The liver

enlarges, sometimes irregularly, and nodular areas, which often gradually become fluctuant, appear on its surface. Infective complications with pyrexia are common, but the disease is essentially chronic, symptoms extending over a period of a year or two.

In some ways this disease simulates carcinoma very closely, as it usually occurs in middle age, but its chronicity is an important diagnostic feature. The immunity tests to ordinary hydatid antigen are usually positive.

(4)—Treatment

Although in a few recorded cases complete excision of the tumour has been carried out successfully, the tumour is generally much too extensive for this procedure. In most cases operation appears to be futile, and in the present state of knowledge the prognosis is hopeless.

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HYDATIDIFORM MOLE

See CHORIONEPITHELIOMA AND HYDATIDIFORM MOLE,
Vol. III, p. 216; *and* PLACENTA, DEVELOPMENT AND DISEASES

HYDRAMNIOS

See PREGNANCY

HYDROCELE

See TESTIS AND CORD DISEASES

HYDROCEPHALUS

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Reference may also be made to the following titles:

BRAIN TUMOUR CEREBROSPINAL FLUID

1.—DEFINITION

702.] In its broadest sense this title includes all conditions in which there is an increased volume of cerebrospinal fluid within the skull.

2.—AETIOLOGY

General aetiology

Cerebrospinal fluid The cerebrospinal fluid is secreted by the choroid plexuses into the lateral ventricles, permeates through the interventricular foramen (foramen of Monro), third ventricle, and cerebral aqueduct (iter of Sylvius), and by way of the foramina in the roof of the fourth ventricle enters the subarachnoid space. Within this space it surrounds the spinal

cord and brain. It is absorbed through the arachnoid villi which invaginate the walls of the intracranial venous sinuses. (See Vol. III, pp. 53 and 356.)

Theoretically hydrocephalus may be caused by the following conditions:

(i) Obstruction to the flow of cerebrospinal fluid between its source and the channels of absorption. This may result from blockage of one or other side of the foramen of Monro, the third ventricle, cerebral aqueduct (iter of Sylvius), fourth ventricle, or foramina of Magendie and Luschka; or it may occur as the result of obliteration of the subarachnoid channels surrounding the brain-stem, with the result that the cerebrospinal fluid after leaving the ventricular system is unable to find its way upwards to the arachnoid villi. Obstruction at one point or another is the common cause of hydrocephalus. *Obstruction*

(ii) Excessive secretion. This may result from venous congestion of the choroid plexuses, as for instance when one of the lateral sinuses is thrombosed. *Excessive secretion*

(iii) A defect in the mechanism of absorption. In animals a suspension of carbon particles injected into the cerebrospinal fluid causes hydrocephalus apparently by plugging the arachnoid villi. Indubitable examples of this cause of hydrocephalus have not been observed in the naturally occurring disease. *Defective absorption*

For practical purposes hydrocephalus is usually classified as congenital or acquired.

Congenital hydrocephalus

Rarely a cause is found for this condition in malformation (e.g. atresia of the cerebral aqueduct) causing obstruction to the outflow of cerebrospinal fluid from the ventricles.

Acquired hydrocephalus

The commonest cause of acquired hydrocephalus is cerebral tumour (see Vol. II, p. 627). Tumours situated in the third ventricle or in the posterior fossa are apt to cause hydrocephalus, even if they are of small volume. Hence, for instance, one of the early signs of a mid-cerebellar tumour in a child may be enlargement of the head. After tumour the commonest cause of acquired hydrocephalus is adhesive meningitis around the fourth ventricle or the brain-stem, such as may result from meningococcal meningitis. Syphilitic meningitis, congenital or acquired, may produce the same result. *Tumours* *Meningitis*

In children and adolescents hydrocephalus may sometimes occur after otitis media (see Vol. IV, p. 436). In these cases there will usually have been thrombosis of one lateral sinus. There are, however, exceptions to this rule, which suggest that inflammation in the neighbourhood of the meninges may, in some way unknown, cause over-secretion of the cerebrospinal fluid or interfere with its absorption. Analogous to these are cases of hydrocephalus following infection of the nasopharynx or *Toxic hydrocephalus*

Trauma

nasal sinuses. These also are encountered almost without exception in children and adolescents. For this group as a whole the term toxic hydrocephalus has been suggested by Mc Alpine. Rarely hydrocephalus may follow head injury without evidence of any gross lesion to account for it. This condition again is more often met with in children than in adults.

3.—PATHOLOGY

*Internal and external hydrocephalus**Pressure effects on skull*

In some instances the increase of volume of cerebrospinal fluid is only compensatory for loss of brain volume, as in congenital or acquired cerebral atrophy. In such conditions there is an increase of the fluid within the ventricles (internal hydrocephalus) and in the subarachnoid space (external hydrocephalus). The accumulation of fluid in these diseases is of no clinical importance. In all other varieties of hydrocephalus the excess of fluid is under increased pressure. As a result of this in the infant or young child the sutures separate and the skull is expanded. In older children and adolescents long continued pressure causes erosion and thinning of the bones. Those of the vault have impressed upon their inner surfaces the outlines of the prominent gyri (see Plate VII), and at the base there are expansion of the sella turcica and erosion of the clinoid processes. The harder bones of the adult are less apt to suffer, and if there is any atrophy it is usually confined to the clinoid processes. In proportion to the distension of the lateral ventricles, the cerebral hemispheres are compressed and may eventually suffer atrophy. If the hydrocephalus is obstructive, the distension is naturally limited to those parts of the ventricular system which lie between the obstruction and the choroid plexuses.

4.—CLINICAL PICTURE

Congenital hydrocephalus

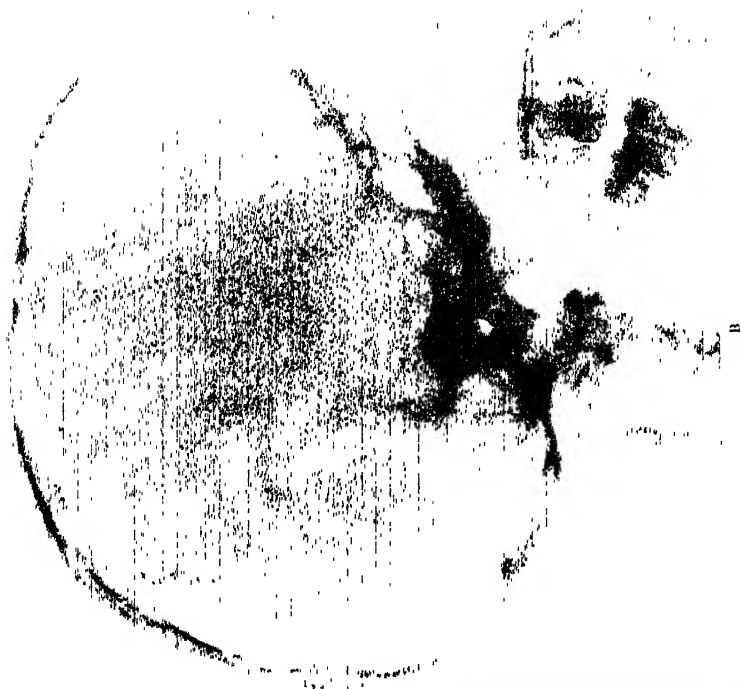
The enlargement of the head may be present at birth and produce dystocia (see Vol. V, p. 369), or it may be apparent in the early days of extra-uterine life. The head is uniformly enlarged, the frontal bones bulge forwards above the eyes, and the eyes are displaced forwards and downwards. The scalp is taut and thin, and its veins are distended. In severe cases the weight of the head prevents the child from retaining a vertical posture, and sores are apt to develop from pressure of the head upon the pillow. Optic atrophy is usually present and sometimes squint or nystagmus. Convulsions are common. The limbs, especially the lower limbs, are often spastic and the plantar responses extensor.

Acquired hydrocephalus

The symptoms of acquired hydrocephalus are those of increased



A



B

A. Horizontal section through brain of child aged 10 days, with congenital hydrocephalus. Aqueduct of Sylvius and 4th ventricle were patent but not distended. (By courtesy of Dr. Felling and Dr. Nevin.) B. Radiograph in case of male aged 19 with long-standing hydrocephalus caused by tumour, showing convolutional markings and slight separation of sutures. (By courtesy of Dr. H. M. Worth)

PLATE VII

intracranial pressure. In the child enlargement of the head with separation of the sutures and a 'cracked pot' percussion note over the coronal (fronto-parietal) suture are conspicuous signs. These are most evident in young children and of slight importance after the age of eight or ten. *Pressure effects*

The less the expansion of the skull the earlier on the whole is the development of other symptoms. Chief among these are headache, vomiting, and papilloedema (see PAPILLOEDEMA). The headache is of bursting character, occipito-frontal or generalized, and in the early stages tends to occur in bouts, especially in the early morning. It may be aggravated or provoked by anything which increases the intracranial pressure, such as coughing, stooping, or straining at stool. The vomiting is usually associated with the headache but may occur independently or with very little headache, particularly in the early morning. It may be very sudden—so-called projectile vomiting—or may be preceded by nausea. Sometimes waves of nausea may occur without actual sickness. Papilloedema as a rule follows headache and vomiting after a short interval, but in some cases the former symptoms may be so insignificant that failing vision from secondary optic atrophy may be the first evidence of grave intracranial disease. *Headache*
Vomiting
Papilloedema

In the later stages of hydrocephalus many other symptoms may occur, such as lethargy, mental deterioration, fits, cranial nerve palsies (especially the sixth), and extensor plantar responses. The distension of the third ventricle may by pressure upon the hypothalamus and subjacent structures lead to drowsiness, obesity, and, in young persons, optic atrophy. The pressure of the cerebrospinal fluid (see Vol. III, p. 56) is increased often above 300 mm. of fluid. Radiography of the skull, in the later stages, shows in a young child separation of the sutures and in an older child or young adult thinning of the skull with convolutional markings on its inner surface (see Plate VII). The clinoid processes may show erosion and the pituitary fossa be enlarged in its antero-posterior diameter. *Later effects*
X-rays

5.—COURSE AND PROGNOSIS

Congenital hydrocephalus

The patients who survive present as a rule, in addition to the enlargement of the head, other symptoms such as mental defect, fits, or optic atrophy, but occasionally in mild cases the large head may be the only relic of the condition.

Acquired hydrocephalus

The prognosis in acquired hydrocephalus depends upon its cause, e.g. in the case of a tumour surgical removal may be possible. In the cases which occur after meningococcal meningitis some patients recover *Meningitic hydrocephalus*

completely, but some are left with a liability to fits and headache and some degree of optic atrophy; the same is true of syphilitic patients. In both groups death may occur suddenly in an exacerbation of increased intracranial pressure, sometimes a considerable time after the inflammation has ceased to be active.

*Toxic
hydrocephalus*

The symptoms of toxic hydrocephalus associated with otitis media, sinusitis, or nasopharyngeal infection often arouse the suspicion of an intracranial abscess. The distinction is not always easy, but the patient with simple hydrocephalus is usually much more alert in mind and fit in body than the patient with hydrocephalic symptoms caused by abscess. Moreover, the cerebrospinal fluid in toxic hydrocephalus, although under increased pressure, does not show any increase of cells or protein.

From toxic hydrocephalus complete recovery is the rule but may be attended by permanent impairment of vision from optic atrophy if treatment is inadequate. In the traumatic cases the patient recovers but may be liable to recurrent headaches.

6.—TREATMENT

Congenital hydrocephalus

Attempts at surgical treatment have so far proved disappointing, and there is nothing to be done but to treat symptoms as they arise.

Acquired hydrocephalus

The treatment of acquired hydrocephalus again depends upon its cause. The reader is referred to the articles on cerebral tumour (see Vol. II, pp. 627 and 637; and Vol. III, p. 67), meningococcal meningitis (see Vol. III, pp. 49 and 62), and cerebral syphilis (see Vol. III, p. 63, and NEUROSYPHILIS). In the toxic and traumatic cases the most satisfactory treatment is repeated lumbar puncture, which should be performed at first daily and thereafter at diminishing intervals. On each occasion the pressure of the cerebrospinal fluid should be recorded and enough fluid removed to bring it down to a normal level (see Vol. III, p. 57). This method of treatment should be continued until the pressure is normal, and the patient should thereafter be kept under ophthalmoscopic observation until the papilloedema has subsided.

*Repeated
lumbar
puncture*

*Intravenous
hypertonic
solutions*

Symptoms of increased intracranial pressure associated with hydrocephalus can be relieved for the time being by the intravenous injection of hypertonic solutions. Of these the most effective are 15 per cent sodium chloride or 50 per cent glucose, the dose for an adult being 50 to 100 c.c.

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HYDRONEPHROSIS

See KIDNEY, SURGICAL DISEASES

HYDROPHOBIA

See RABIES

HYDROTHERAPY

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Reference may also be made to the following title.

CLIMATE IN THE TREATMENT OF DISEASE

1.—DEFINITION

703.] Hydrotherapy, or the remedial employment of water, has to be considered under two headings: (i) the external use of water, whether plain, medicated, or mixed with other media, as well as in the form of vapour and hot air, by means of baths, douches, and packs of various kinds (balneotherapy); and (ii) the internal use of water, either plain or naturally mineralized, including spa treatment.

2.—EXTERNAL APPLICATION (BALNEOTHERAPY)

(1)—Physiological Basis

*Functions of
the skin*

704.] The skin, through its excretory, secretory, and heat-regulating functions, by its vast capillary network capable of controlling the distribution of blood throughout the entire body, and by an intricate nervous mechanism composed of two antagonizing elements of the autonomic system in association with a group of endocrine glands, is primarily concerned with the reaction of the body to its environment. A knowledge of these reactions provides the basis for the rational employment of the external measures to be dealt with below. In directing treatment to the skin, an endeavour is made so to modify its activities that functional disorders of the organism as a whole may be corrected.

The application of heat, cold, various mechanical agents, light, or electricity to the skin calls forth a definite response. This, according to Lewis, is threefold, namely, local vasodilatation, the flare, and local oedema. The local dilatation is due to the liberation of a vasodilator substance, the flare depends on the local nervous mechanism, and the oedema on an independent change in the vessel wall which renders it more pervious. Living epidermal cells are thought to produce the vasodilator, or H-substance.

Response to stimuli

H-substance, which is set free as a result of therapeutic stimuli applied to the skin, can produce an allergic shock, characterized by a period of malaise, pyrexia, and an exacerbation of the general and local symptoms of the malady for which the treatment is being given. This effect is intensified if, in consequence of the measures adopted, inflammatory exudates from the neighbourhood of affected joints or muscular planes are swept into the circulation.

The H-substance

The condition induced in this manner is known as the 'bath fever' or 'thermal crisis' and usually appears a day or two after the treatment has begun; indeed it often necessitates the suspension of treatment for a short time.

Bath fever or thermal crisis

Many persons, more particularly those of a gouty habit, regard the occurrence of a well marked thermal crisis as an excellent augury for the eventual success of their treatment.

(2)—Baths

The external applications of hydrotherapy include the following:

- (i) Immersion baths, either full or partial, consisting of plain, naturally mineralized, or artificially medicated water at varying temperatures.
- (ii) Douches of plain or mineralized water at varying temperatures and pressures, either with or without massage and manipulation.
- (iii) The application of steam or hot air.
- (iv) The use of packs of various kinds.

Varieties

Heat and cold are relative terms. Objects are recognized as cold when they have a temperature below that of the skin. Kellogg classified temperatures as follows: very cold, 32–55° F.; cold, 55–65° F.; cool, 65–80° F.; tepid, 80–92° F.; warm (neutral) 92–98° F.; hot, 98–104° F.; and very hot 104° F. and above.

Range of bathing temperatures

(a) Immersion Baths

The therapeutic effects of an immersion bath are due to the mechanical and thermal action of the water on the skin and, through it, on the deeper structures.

General effects

The mechanical effects depend on the pressure of the water on the parts immersed, and the resistance offered to this pressure by different portions of the circulatory system. The great vessels are affected least, since their walls are under a pressure of from 70 to 120 mm. Hg, upon which the pressure from the forty or fifty gallons of water in the bath can have relatively very little influence. The veins, capillaries, and

Mechanical effects

smaller arteries, however, are under direct pressure, the net result of which is to raise the peripheral tension and increase the work of the heart.

As regards the abdomen, the hydrostatic result is a decrease in splanchnic stasis. Pressure on the thorax facilitates expiration at the expense of inspiration. In the veins the pressure increases the 'vis a tergo' but at the same time it collapses the walls of the vessels and causes more friction on the blood against them. The two effects would seem to cancel each other out.

Owing to the support afforded by the water, the movements of limbs can be carried out with much less effort when they are submerged than in ordinary circumstances. This is particularly well seen in the case of stiffened joints and wasted muscles, in which a degree of mobilization can be attained that would be quite impossible otherwise.

Thermal effects depend entirely on the intensity of the heat and the length of its application. As these vary according to the kind of bath, they will be considered in the description of the various baths.

Thermal effects

Cold immersion baths

These baths are usually given at a temperature between 50° and 70° F. They should not last more than a few seconds unless vigorous movement of the limbs is kept up or friction applied to the body during the period of immersion. Cold bathing is only for the robust, and is mainly employed to tone up the skin after hot applications and to provoke a definite reaction (see below).

Indications

General effect of cold applications

The first effect of a cold application is to lessen bodily activity. This continues throughout the application but directly after its removal, provided it has not been continued too long, the return to normal is marked by a reaction. Cold at first excites the peripheral nerves, and among the surface phenomena associated with its application are pallor and coldness of the skin, reflex inhibition of sweating, and decreased heat elimination. If the application is prolonged there result decrease of muscular irritability, slowing of the heart, increase in arterial pressure, and leucocytosis. The effects of cold depend on the length of its application and on the reactive powers of the patient. Short applications are very effective stimuli to metabolism.

Reaction following cold bathing

Kellogg summarized the phenomena of the reaction to cold baths as follows: 'Dilatation of the superficial vessels, which produces a pink, soft, smooth and supple skin; increase of perspiration; a sense of warmth and well-being; slowing of the pulse with slightly increased tension; fall of internal temperature; respiration, free, slow, and deep'.

Conditions favourable for a reaction

As it is most important that a reaction should follow all cold applications, it must be remembered that the conditions which favour it are: warm clothing, a hot bath of some kind immediately preceding the cold, exercise and friction of the skin, and a warm room to rest in afterwards. Elderly subjects with arteriosclerosis, young children, and persons with a rheumatic tendency do not as a rule react well to cold applications.

Unsuitable types of patient

Hot immersion baths

The temperature of hot baths ranges between 100° and 106° F. and should be gradually raised from about 96° F. to the required degree. They should never be unduly prolonged; at the higher degrees one or two minutes will suffice owing to the risk of causing faintness, and at about 100° F. ten or fifteen minutes is the usual duration. A complete immersion bath at 110° F. is unendurable for most Europeans, but the Japanese are well accustomed to such baths at 130° F.

The effects depend on the temperature and duration. Moderate heat relaxes the surface vessels; great heat constricts them at first, producing pallor and slight shivering which quickly disappear as they relax. The activity of the sweat and sebaceous glands is increased.

As the sweat cannot be evaporated and thus cool the surface of the body, heat accumulates internally and the temperature of the body rises accordingly. This is one of the most important effects of a hot immersion bath. The induction of artificial pyrexia is now regarded as a therapeutic measure of considerable value and the range of its application is increasing.

Of the three great vascular areas—the skin, the muscles, and the portal system—if one is engorged the others must be more or less depleted. Dilatation of the peripheral capillaries induced by a hot bath temporarily ‘decongests’ the deeper organs. The capillaries in the skin are, in fact, said to be capable of containing two-thirds of the entire blood-supply of the body. The opening up of the vessels of the skin has a further effect—namely, a lowering of the pressure in the larger arteries.

Respiratory movements are facilitated by moist heat, but the amount of tidal air is diminished. Short applications have a reviving effect, whereas prolonged applications diminish muscular excitability.

Hot baths are mainly prescribed as diaphoretic measures. When they are followed by a full pack (see p. 587), profuse sweating is evoked. They are valuable in the treatment of rheumatism and fibrositis, chronic bronchitis, nephritis, dysmenorrhoea, and intestinal colic, and as a palliative remedy in gall-stone and renal colic.

Hot baths should be avoided in organic disease of the central nervous system, myocardial affections, and cardiac hypertrophy. Extreme caution should be observed in prescribing them in arteriosclerosis.

The nearer the temperature of the bath approaches that of the body the less marked is the reaction. Very hot unduly prolonged baths are characterized by a reaction which Kellogg sums up as follows: ‘Vaso-constriction; pallor of the skin; a frequent low-tension pulse; frequent, free and superficial respiration; lessened perspiration; gradual cooling of the skin; depression of internal temperature from increased heat elimination and decreased heat production; diminished nervous and mental irritability; drowsiness and depression; muscular weakness and indisposition to muscular effort’.

*Effects**Production of pyrexia**Effects on the circulation**Effects on other systems**Indications**Contra-indications**Phenomena of reaction*

The warm or neutral bath

Effects This is known also as the 'bath of thermal indifference'. It is given at a temperature of from 93° to 94° F., for from fifteen minutes to an hour or longer and is purely sedative. The pulse rate is diminished but the respiration is unaffected. Surface temperature is lowered. There is no reaction.

Indications It is used chiefly in cases of insomnia, psychathenic states, and many nervous affections.

The cool or tepid immersion bath

The temperature of cool or tepid baths ranges between 70° and 90° F.; it should begin at 90° F. and be lowered gradually to the required degree. These baths may be given for half an hour or longer. Their chief action is to abstract heat and slow the pulse.

Indications They may be used as an antipyretic measure in the treatment of long, continued fevers, and also in delirium tremens in which they diminish tremor and the toxic features of the condition.

Pool baths

These baths may be given with either plain or mineralized water. They are usually found only at the spas, and the local mineral water is generally employed. The pool should be of sufficient size to allow the patient to take a step or two and to perform movements at the hip joint in a standing position. The temperature of the water ranges between 100° and 104° F. A comparatively low temperature is regarded as more suitable for the subacute type of case, and the higher for the more chronic cases which require stimulation.

The under-water douche The under-water douche is a most valuable adjunct to this treatment. It is given at a temperature ten degrees higher than the bath. Besides its striking effects in relieving pain, it has a most powerful action on the peripheral circulation, which can easily be seen by watching the depression of the skin immediately below the point of impact of the stream. The nozzle of the hose-pipe delivering the stream can usually be held by the patient and directed towards the painful areas.

Indications The pool bath is perhaps seen at its greatest advantage in the treatment of morbus coxae senilis. The warmth of the water lessens muscular spasm, which is just as potent a cause of crippling as bony changes. The water also reduces the weight of the limb. The pool bath with the under-water douche is also of great value in the treatment of capsulitis of the shoulder when accompanied by brachial neuralgia or neuritis.

Naturally mineralized or medicated baths

The presence of a salt or medicament in water increases its specific heat and renders it more stimulating to the skin. The following kinds of bath are in common use.

Sea-water baths

Immersion of the body in sea-water, in an ordinary reclining bath, has precisely the same effect as that obtained from a weak brine bath (see below). The percentage of total salts in sea-water varies between 3 to 4 for the Red Sea and Mediterranean and 0.7 to 1.7 for the Baltic and Black Seas. The concentration of sodium chloride, the salt present in greatest proportions, is about 3 per cent in the Red Sea and Mediterranean, and considerably less in the Baltic. Droitwich brine contains 31 per cent of sodium chloride.

*Percentage
of salt in
sea-water*

In sea-bathing, other factors come into play—namely, the exposure of the body to the fresh and invigorating atmosphere, direct irradiation from the sun, and the powerful effect on general metabolism produced by the stimulus of the waves impinging on the body. Persons bathing in a fairly rough sea take finely divided sea-water into the lungs by the inhalation of spray. On immersion of the body the shock causes deep inhalations and consequent expansion of the lungs with pure sea-air. The cooling of the surface of the body is followed by a reaction with superficial dilatation of the peripheral vessels. By the action of the heat-regulating mechanism the circulation undergoes alteration and richly oxygenated blood is distributed throughout the body. The best results are undoubtedly brought about by a short bathe. The custom of sitting about in wet bathing costumes should be deprecated, as chills frequently result.

Sea-bathing

Children should when possible be given a hot drink after bathing and protected from possible chills by warm clothing. At Hayling Island, where therapeutic bathing is carried out, the children are placed in a pen on a warm planked floor in the centre of which is placed a large iron brazier with a coke fire burning therein. The combination of a hot sun and a cold sea is responsible for many childish ailments at the sea-side.

Children

Brine baths

For the preparation of a brine bath at a strength approaching that of the sea, five or six pounds of sea salt (e.g. Tidman's) should be added to a bath of forty gallons of water. The duration is from fifteen to twenty minutes. The temperature should be varied according to the effect desired: as a tonic or stimulant from 90° to 97° F., and for the production of profuse sweating, between 100° and 105° F. After the bath the patient should be wrapped in hot blankets to encourage continuance of the perspiration.

The strongest natural brines are at Droitwich, Rheinfelden, Reichenhall, and Bex-les-Bains.

*Natural
brines or
muriated
waters*

Brine baths, either natural or artificial, are mainly used in the treatment of rheumatic affections, perhaps more particularly in the non-articular type.

Indications

Aeration baths

With the water at a temperature of 98° F. air is driven in by means of an apparatus consisting essentially of perforated pipes connected with an air pump. The bubbles of air by constant impact on the surface of the body exert a soothing influence.

Indications The treatment is employed in the earlier or painful stages of fibrositis when the ordinary douche-massage cannot be used. It is also prescribed in neuritis and neuralgia. Aeration baths can be given to weakly patients in circumstances in which for a more or less robust individual a brine bath would be appropriate. A very satisfactory effervescing or aeration bath can be prepared by using Nauheim bath salts which can be obtained from any chemist.

Natural effervescing baths

Gaseous or aerated waters for bathing purposes are found at Nauheim, Oeynhausien, Royat, and Spa. Their chief indication is in the treatment of arterial hypertension.

Sulphur baths

Baths of natural sulphur water are available at Harrogate, Strathpeffer, Llandrindod, Buda Pest, Aix-les-Bains, Aachen, and Uriage.

Artificial sulphur bath

For the preparation of a sulphur bath four to ten ounces of sulphurated potash may be added to an ordinary bath. A preparation known as 'sulphaqua', supplied in charges each of which is enough for one bath, has the advantage of not spoiling an iron bath-tub.

Indications

Artificial sulphur baths are extensively used in the treatment of various skin affections, mainly parasitic. They are occasionally prescribed in rheumatic conditions, but it is doubtful if they possess any advantage over a brine or salt bath. Baths of natural sulphur water, particularly those with a high content of sulphuretted hydrogen, are employed in acne, lichen, and some forms of seborrhoea, with, in many instances, gratifying results.

Foam baths

Foam baths are produced by liberating carbon dioxide into water to which a small quantity of saponin has been added, or by the addition of such substances as sulphonated lorol followed by violent agitation of the water. The body is covered with a thick white foam which effectually prevents the radiation of heat from the surface. The consequent accumulation of heat internally causes a rise in temperature with profuse sweating. Except for its comparative novelty the foam bath has not any advantage over other 'sweating' baths.

Mustard baths

These are prepared by adding from a half to one ounce of mustard to each gallon of water. The required amount should be mixed with a little cold water before its addition to the bath. Colman's mustard bath

cartons, each of which contains the exact quantity necessary for one bath, are very convenient. The bath temperature should be about 102° F. and its duration from ten to twenty minutes according to the toleration of the patient's skin.

The volatile oil contained in the mustard irritates the skin and, no doubt by the action of the H-substance, dilates the capillaries; the deeper organs are correspondingly 'decongested'. The flushing of the skin with blood stimulates sweat secretion.

The mustard bath is for some unexplained reason one of the most reliable of domestic remedies in cases of infantile convulsions.

In many forms of neuritis—sciatic, intercostal, or brachial—as well as in cases of generalized fibrositis, a mustard bath relieves pain.

Cutaneous hyperaemia

Children's diseases

Rheumatic diseases

Mud and peat baths

Mud is a mixture of finely comminuted rock particles with water. Its consistency varies and it may either be deposited from suspension in water or ejected from volcanoes. Peat is vegetable matter decomposed by water and partly carbonized by chemical change, often forming bogs or mosses.

Mud and peat

A general application of mud or peat can usually only be obtained at spas. The usual procedure is to mix the mud or peat with either plain or mineralized water and, after placing it in an ordinary reclining or slipper bath, to heat it to the required temperature by a jet of steam. After an immersion of from twenty to thirty minutes, the adherent mud is washed off the body and the patient is packed in hot sheets and left to sweat for about half an hour. The temperature of the bath is usually about 104° F.; it is only given on alternate days at the most. Another method is to apply the mud or peat as a general covering, after which a mackintosh sheet and blankets are tucked round the body for the usual time. A needle or shower spray followed by a warm dry pack completes the treatment.

Application

As mud and peat have a higher specific heat than plain water, it takes longer for the equalization of temperature to occur between the body and the medium in which it is lying. Owing to the retention of heat, a rise in the body temperature always occurs. With the evaporation of the copious sweat which follows the bath the temperature soon returns to normal.

Effects

A general cutaneous stimulation is also promoted by the vegetable and mineral elements contained in the mud or peat; in short the effect of a general application of mud is much like that of a universal poultice.

Hyperaemia of the skin promotes absorption of oedematous swellings in the region of the joints or among muscular fibres and fascial planes; thus, provided that the patient is sufficiently robust, mud baths are indicated in the treatment of practically every kind of chronic rheumatism, whether articular or non-articular.

Indications

Chronic rheumatism

Owing to the decongestive effects of a generalized application, mud

- Pelvic inflammations* baths are extensively employed in the treatment of pelvic inflammations, especially in cases in which the functional activity of the various organs is interfered with by the presence of inflammatory exudates.
- Obesity* Cases of obesity due to lack of exercise or over-eating do very well under this treatment, especially if the diet and habit of life are carefully regulated.
- Local application* If the patient cannot go to a spa, local applications of mud or peat can be carried out. The packs are prepared in very much the same manner as a linseed poultice. To a large tin or basin containing very hot water, powdered fuller's earth is slowly added and, when the required consistency is attained, the mass is spread on a piece of linen and applied to the part it is desired to treat. The whole is then covered with a waterproof sheet and a blanket. Mud from some of the spas can be procured and when made up into a compress can be used over and over again. Fuller's earth can only be used once, but as it is very cheap this is not a very great drawback.
- Indications* Local mud or peat packs are employed in very much the same type of case as the full bath. In almost all forms of rheumatism lumbago, brachial neuralgia, gluteal fibrositis, and sciatic pain a pack of hot mud, peat, or fuller's earth is most comforting. For some unexplained reason, moist heat is always more beneficial than dry heat for pain in the sciatic region.
- Climacteric arthritis* In climacteric arthritis which occurs in the knees of middle-aged women, considerable relief from the pain can be obtained by the application of a mud or peat pack three or four times a week. Its good effect will be further enhanced if care is taken to correct any static deformities of the feet.

Partial immersion baths

A thermal stimulus applied to a comparatively small portion of skin affects its whole area. Therefore, in order to promote a rise of internal temperature and induce sweating it is not necessary to immerse the whole body in the heating medium.

- Varieties* Partial baths may be in the form of sitz, leg, hand, or arm baths.

Sitz baths

The large vascular area comprised in the intra-abdominal viscera may be regarded as a reserve of flexible dimensions and capable of acting as a pressure regulator for the entire vascular system. If the pelvis and hips are immersed in very hot water or other medium, it is this vascular area that is acted upon.

- Indications* The cutaneous hyperaemia induced by a very hot sitz bath will relieve the congestion of deeper organs—uterus and adnexa. Combined with a cold spray to the lumbar region, it often relieves urinary retention; and combined with a hot abdominal pack, it has proved very efficacious

in the treatment of the flatulence and meteorism associated with psychasthenic states.

Leg baths

Leg baths when given at a comparatively high temperature are of value in the relief of muscular pain. If they are given in the same manner as arm baths (see below) the internal temperature may be raised and sweating promoted. The latter is often aided by a stimulant such as a little whisky or rum and hot water.

The glove bath

The hands enclosed in rubber gloves a few sizes too large, or the feet encased in rubber socks or large sponge-bags, are immersed in hot water maintained at a temperature of from 110° to 120° F. for twenty minutes to half an hour daily. An ointment of methyl salicylate, iodine, or menthol may be applied before putting on the gloves or socks.

Owing to the retention of heat and the elevation of the local internal temperature, the hands and feet when the coverings are removed are bathed in a copious perspiration and are much more supple. *Rationale*

These baths are useful for arthritic changes with consequent stiffness, pain, and swelling, in the wrists, fingers, ankles, and feet as well as sprains or strains to those parts, for stiffness following old injuries, and for fibrositis of the plantar or palmar fascia. They are also useful in the manipulative treatment of flat-foot, to induce muscular relaxation.

Arm baths

These are usually given in a specially constructed apparatus with a device for gradually increasing the heat of the water at the rate of about one degree every two minutes. The same effect can be produced by removing a cupful of water every two minutes and replacing it with hotter. *Indications*

Gradually increasing heat stimuli progressively dilate the peripheral vessels and reduce arterial pressure (Hauffe). The local application of heat in this manner is also used to exert a general action in the circulation of patients who are unable to take a full immersion bath. *Indications*

Whirlpool baths

Either an arm or a leg may be treated. The arm bath is like a baby's bath, and the leg bath is deeper and cylindrical.

The water is agitated by an electrically-driven turbine which produces a current directed round the sides of the vessel. This current of hot water is very soothing in painful conditions resulting from operation wounds or amputations. The whirlpool bath is used in orthopaedic centres and general hospitals for accidents to limbs. *Indications*

(b) *Douches*

Definitions: simple and manipulative Perhaps the best definition is Kellogg's; 'a single or multiple column of water varying in temperature, pressure, and mass' directed against some portion of the body. Such a douche is known as 'simple' when given alone, and 'manipulative' when combined with massage.

Description Pressure depends on the height of the source of the supply; the mass may be anything from a filiform douche as fine as a needle to a column of water an inch in diameter, and the column or columns may take the form of jets, fans, rains, or showers in horizontal, descending, multiple, circular, or ascending directions.

Simple douches

Cold douche The cold douche is given at 55° to 60° F. for a few seconds at a high pressure in order to bring about a reaction. Its chief indications are those of a general tonic and stimulant. It also forms part of the contrast douche mentioned below.

Hot douche The average temperature of the hot douche is between 110° and 115° F. It should begin at 100° F. and be gradually raised. At the higher temperature the stream must be kept in constant motion to obviate the risk of scalding. It should last for a few seconds only or a minute at most at the higher levels of temperature.

Indications Its indications are much the same as those of the hot immersion bath (see p. 577); its effects are also similar, with the addition of the mechanical factor of pressure.

Neutral douches A warm or neutral douche at a temperature between 92° and 97° F. has a soothing effect and can be used with advantage in cases of insomnia and nervous excitement.

Contrast douche The contrast douche is often referred to as the 'Scottish' or 'alternating' douche. It is carried out by two hose-pipes, one delivering very hot and the other very cold water. The cold application is given for 3 to 10 seconds at a time; the hot douche lasts from 12 to 40 seconds, the duration of the treatment being from 6 to 10 minutes in all.

Indications The alternating pallor and redness of the skin coinciding with the change from cold to hot show that the peripheral circulation is affected; and there is therefore reason to assume that the movement of lymph in the lymph spaces is facilitated. Given along the spine, the contrast douche has a pronounced tonic effect. Old inflammatory deposits in the subcutaneous tissues are often dispersed or much decreased in size by this treatment. It is also very valuable in the later stages of sciatica and brachial neuralgia, but is contra-indicated in the earlier stages of these affections.

Needle baths Needle baths have numerous fine jets of water either cold, neutral, or hot, which play on the surface of the body. These baths are sometimes given in combination with the contrast douche.

Manipulation douches

For manipulation douches the patient may be either seated on a stool or chair and the massage given by the operator with a hose-pipe over his shoulder, the stream being directed to the part under treatment (Aix system); or he may lie on a table above which is suspended a pipe with a number of rose jets delivering fine streams of hot water which impinge on the body during the massage (Vichy system).

The fingers and hands of the operator glide smoothly over the softened parts, grasping and squeezing the tissues, and thus produce effects on peripheral nerve-endings and on the vessels of the cutaneous and subcutaneous circulation. In this manner the blood-supply to the parts is increased, stasis in capillary areas relieved, nutrition improved, and the reparative powers of the patient generally stimulated. Manipulation douches are valuable therefore in the treatment of all chronic inflammatory conditions associated with the rheumatic state. *Indications*

(c) Colonic Irrigation

The technique of colonic irrigation, the irrigation solutions, and the indications for their use are described under the title ENEMAS AND COLONIC IRRIGATIONS, Vol. V, p. 37. At the spas, e.g. Harrogate, Llandrindod, and Chatel-Guyon, the local mineral water is used as the irrigating solution; an alkaline water is usually selected. When available, a reclining bath at a temperature of 102° F. with an under-water douche at 112° F. is given after the irrigation. The douche should be played gently round the abdomen in the course of the colon, for about five minutes or more. This procedure has been found to be most soothing in cases of colitis and in spastic conditions. *Douche sous-marine or 'Tivoli' douche*

(3)—Steam or Hot-Air Baths*Steam or vapour baths*

These are either general or local. In the former, the vapour may be derived from boiling water and introduced into a special room, or it may be given off from hyperthermal waters such as are found at Bath, Chaudes Aigues, Buda Pest, Dax, and Plombières. The checking of evaporation from the surface of the body thus produced results in heat being retained with a consequent rise in internal temperature. *Effects*

The indications for the full bath are much the same as those for the full immersion bath. It is a powerful diaphoretic measure and of value in many disorders of metabolism. It is very tiring and if given at a high temperature is very apt to cause fainting. The bath should be used only for the robust type of patient and never for the old and feeble. More casualties, such as fainting, arise in connexion with the full vapour bath than with any other hydrotherapeutic measure. *Indications*

Local vapour baths are best given in the form of the Berthollet bath,

Berthollet bath

which consists essentially of a large metal cylinder into which steam is introduced either by means of a pipe from a source of supply or as vapour from the local hyperthermal mineral water, as at Aix-les-Bains and other spas. The patient sits outside the cylinder and introduces the limbs into the four openings provided at its side. All four limbs are placed in together, but in prescribing the treatment it is usual to specify which are to be specially massaged after the bath. The apertures are provided with mackintosh cuffs to prevent the escape of too much vapour. Although the limbs alone are placed in the chamber, most profuse sweating takes place all over the body. After about twenty minutes' exposure to the steam, the affected part is massaged for ten minutes.

Indications

Treatment by the Berthollet bath is valuable in dealing with stiffened knees, ankles, wrists, or elbows. Cases of osteoarthritis of the knee appear to do exceptionally well.

Hot-air baths

The hot-air (e.g. Turkish) bath differs from the vapour bath in that the air is dry and evaporation of sweat from the surface of the body takes place readily. The internal temperature is therefore not raised. Cutaneous circulation is stimulated and congestion of the deeper organs correspondingly relieved.

Indications

This treatment is indicated in obesity due to irregular habits and insufficient exercise, in gout, and in many rheumatic disorders.

*Radiant-heat baths**General bath*

A general radiant-heat bath is given by means of a cabinet containing some forty-eight or more incandescent lamps. The head of the patient is outside, so that much purer air is available than in the flue room of a Turkish bath (see also HEAT, RADIANT, p. 385).

Effects and indications

The action of this bath is very much the same as that of the Turkish bath—namely, the induction of a free perspiration—and it has very much the same indications.

Local applications

The source of heat for local applications is usually a number of incandescent lamps which are fixed inside an appliance which fits over the portion of the body to be treated. Sometimes a single lamp of high candle-power is employed, but it is immaterial how the heat is produced; two hot bricks at the bottom of a bucket are just as efficacious as the most elaborate electrical contrivance.

Relief of pain

The application of heat for the relief of pain is almost instinctive in men and animals. The nerve fibres that convey impressions of heat and cold to the cortex are also utilized to convey impressions of pain (Starling), and it therefore follows that if the application is sufficiently intense the nerves may be temporarily blocked and painful impressions fail to reach the sensory areas.

(4)—Packs

Wet packs

The patient is packed up in a sheet wrung out in water at a temperature between 60° and 80° F. and covered with blankets. The duration of the treatment is from half an hour to one hour or longer.

The first effect of a wet pack when given at a fairly low temperature is *Effect* to irritate the peripheral vessels and nerves and cause a contraction of the former which lasts until a reaction takes place.

With the onset of reaction the cutaneous vessels dilate and warmed *Reaction* blood flows to the periphery from the deeper vessels. With the raising of the temperature of the skin the sheet in contact with it becomes heated, and this results in vaporization from the sheet and consequently a loss of heat from the skin.

The elimination of sweat is greatly helped by a prolonged application *Elimination* of the wet pack. That this takes place is often proved by the odour of the vapour which, if a series of wet packs is given, becomes progressively fainter.

When the temperature of the sheet and of the skin are more or less *Sedative* approximated, the patient often becomes very sleepy. This may be due *effects* to the relative anaemia of the brain brought about by determination of blood to the surface. When sedative effects are desired, the patient may be allowed to remain three or four hours in the same pack, and sleep should be encouraged. When the pack is finally removed, a cold sponge or needle bath should be given. In insomnia and restlessness the full wet pack may take the place of hypnotics, but, as it entails much more trouble, its extended use can hardly be expected.

Half wet pack

This is more convenient to apply than the full pack. The pack is applied *Indications* to the lower half of the body from the waist downwards. Unless otherwise specified, the sheet is wrung out in cold water. The indications are very much those of the full pack.

Hot abdominal pack

A flannel pad folded three times and reaching from the ensiform cartilage to the pubes is wrung out in water at 110° F. After the pack has been applied the whole is covered with a mackintosh sheet, and blankets well tucked in at the sides. The duration is about half an *Indications* hour. The hot abdominal pack is very useful in spasmodic attacks of abdominal pain, such as occur in spastic colon and biliary or renal colic. Care must be taken not to overlook an inflamed appendix or other organic lesion. The combination of the hot abdominal pack with a hot sitz bath is valuable in the treatment of flatulence and meteorism so often seen in psychasthenia (see p. 582).

Mustard packs

<i>How to prepare</i>	For the preparation of mustard packs mustard bran is preferable to ordinary mustard, because it absorbs water more readily. A small hand-towel or square piece of calico of about that size is wrung out in hot water and laid on a table. Over one half of the fabric mustard bran is freely sprinkled; the other half is doubled over, and the superfluous water squeezed out.
<i>Liver pack</i>	If intended for the liver, a pack thus prepared is placed on the patient's right side reaching from the nipple to the umbilicus and from the middle line anteriorly to the mid-line of the back. The blanket upon which the patient lies is brought over and tucked under each flank. The pack should remain in position for about twenty minutes, after which a needle bath or cold douche to the spine should be given. The mustard liver pack is extensively used in British spas, more particularly those with aperient waters. It is very popular among patients of a gouty habit who lead sedentary lives and habitually overeat. It is also of benefit in the early stages of alcoholic cirrhosis and in the so-called tropical liver.
<i>Indications</i>	
<i>Spinal pack</i>	A mustard pack as prepared above is applied to the upper part of the spine and the patient is wrapped in a blanket, usually for about twenty minutes. Tepid or cold sponging follows or a needle bath if available. The spinal pack when combined with contrast douches is most invigorating and may be prescribed with advantage in anaemia and debilitated states.
<i>Indications</i>	
<i>Other applications of mustard packs</i>	The value of a mustard pack or cloth is not sufficiently appreciated. It is an excellent counter-irritant, and most gratifying results have been obtained by its use in the earlier stages of sciatica, brachial neuritis, pleurodynia, and lumbago.

(5)—Paraffin Wax

<i>Method of preparation</i>	The application of paraffin wax can scarcely be regarded as a hydrotherapeutic procedure, and the only reason for its inclusion under this heading is that it is so often used in conjunction with hydrotherapy. Paraffin wax melts at about 122° F. and a hand or foot can be immersed therein at a temperature of from 125° to 130° F. If the affected part cannot be immersed, the melted wax can be painted on in six successive coats, each one being allowed to dry before another is applied.
<i>Effects</i>	When a hand or foot with a surface temperature of 92° F. or thereabout is thrust into melted wax at a temperature of 125° F., a film of hardened wax at once forms and protects the skin from scalding. During solidification, the wax in contact with the part contracts and squeezes out the blood from the surface. Between the skin and the wax a copious flow of sweat takes place which further obviates the risk of burning. The wax cannot absorb this, and the limb or part is bathed in sweat induced by the internal heat. The surface vessels

are hardly dilated at all, as seen by the pallor when the wax is stripped off. The part very quickly reddens directly the compression is removed.

In many respects paraffin wax may be looked upon as a very intensified form of mud or peat treatment (see p. 581). It is much used in arthritis of the fingers, wrists, elbows, knees, ankles, and feet. In capsulitis of the shoulder and inflammatory conditions of the subdeltoid bursa, applications of paraffin wax have proved most effectual. They are also employed with considerable success in strains and sprains of joints accompanied by tenosynovitis. In these instances the applications are generally combined with massage. *Indications*

3.—INTERNAL EMPLOYMENT OF HYDROTHERAPY

(1)—Sources of Mineral Waters

705.] Mineral waters are found as either cold or thermal springs.

Cold springs originate in two ways: (i) from underground water formed by the percolation of rain until it reaches an impermeable stratum; and (ii) from 'main' or deep springs which issue through a fault in regular geological formations such as chalk or sandstone. *Cold springs*

When granite or other crystalline rock is subjected to immense heat, the water of hydration is driven off as steam. If, owing to a fault, a subsidence of a mass of granite into the heated interior of the earth takes place, steam may be evolved at an enormous pressure which at a later stage condenses. Mineral salts from the igneous rocks are carried up by the water, and some of these are deposited in veins, the rest coming to the surface. *Hot springs*

All mineral waters readily transmit electric currents. The salts they contain, being in very dilute solution, are dissociated into ions which, on passage of a current, are directed towards the electrodes—positive ions to the kathode and negative ions to the anode. Elements are liberated in proportion to their equivalent weights (the equivalent weight being the atomic weight divided by the valency). Thus a current which would liberate 1 gram of hydrogen would also liberate 8 grams of oxygen, 108 grams of silver, and so forth. *Electrolytes*

The results of analysis of mineral waters may be expressed in terms of grains of solids per gallon, in parts per hundred thousand, or in parts by weight in 100,000 of ions or salt components. *Analysis of mineral waters*

(2)—Types

The following is a list of the main types of natural mineral waters, described in terms of their dominant or most active elements.

Simple cold springs, though very feebly mineralized, often less than a

- Simple cold springs* domestic supply, contain a relatively large amount of free carbon dioxide to which they owe their palatability. Examples: Malvern, Balaton Füred (Hungary), Bad Brambach, Pyran, Fiuggi (Italy).
- Simple thermal springs* Simple thermal springs are used more for bathing than drinking. Their mineralization is very feeble. Examples: Bath, Buxton, Badenweiler (Black Forest), Bagnolles de l'Orne, Battaglia, Dax, Badgastein, Luxeuil-les-Bains.
- Muriated waters* Muriated waters have as their chief constituent common salt. Its proportions vary from the feebly mineralized Kochbrunnen at Wiesbaden (0.2 per cent) to the highly concentrated brines of Dronowich and Reichenhall (31 and 2.2 per cent respectively). Examples: besides those mentioned above, Bourbon-Lancy, Woodhall Spa, Kreuznach, Salsomaggiore, Bex-les-Bains, and Rheinfelden.
- Alkaline waters* Alkaline waters have as the chief solid constituent sodium bicarbonate. Free carbon dioxide is also contained in large amounts. Depending on the presence of other salts the following subdivisions are recognized: (a) Simple alkaline waters containing mainly sodium bicarbonate and carbon dioxide, as found at Salzbrunn and Vichy. (b) Muriated (sodium chloride) alkaline waters such as occur at Fms, Gleichenberg, Lubacovie, and Royat. (c) Sulphated alkaline waters containing sodium sulphate as well as the bicarbonate, such as are obtained at Franzensbad, Marienbad, Karlsbad, and Tarasp.
- Sulphated waters* Sulphated (bitter) waters contain as their chief ingredients sulphates of sodium and magnesium. The latter salt gives them their bitter taste. They are very strongly mineralized, and mainly supplied as bottled waters for home consumption. They have a very strong aperient effect. Examples: Franz Josef, Hunyadi Janos, Apenta, Rubinat.
- Muriated sulphated waters* Muriated sulphated waters are placed in a separate group, because their mineralization is very feeble when compared with the sulphated (bitter waters) group. They are found at Cheltenham, Leamington, Saint-Gervais, and Saint Vincent. The Montpellier spring at Cheltenham contains two parts per thousand of sodium sulphate, whereas Hunyadi Janos contains seventeen.
- Earthy waters* Earthy waters contain in solution salts of the alkaline earths, calcium, magnesium, barium, and strontium. At Chianciano, La Roche-Posay, and Wildungen they are mostly carbonated, while the sulphated (gypsum) occur at Bridge of Allan, Bagnères-de-Bigorre, Contrexéville, and Vittel. It will be remembered that the calcium carbonate causes temporary hardness and that the sulphate is responsible for permanent hardness in a water.
- Sulphur waters* Sulphur waters are of three kinds, namely: (a) Those in which the chief mineral solid is sodium sulphide and sometimes calcium sulphide; these waters are mainly thermal and can be found at Amélie-les-Bains, Baden (Austria), Barèges, Buda Pest, Cauterets, Luchon, and Vernet-les-Bains. (b) The gaseous sulphated group highly charged with sulphuretted hydrogen; these are found at Strathpeffer, Allevard, Aix-les-Bains, Schinznach. (c) The group in which common salt is present in addi-

tion to the sulphides: these are known as 'muriated sulphuretted waters' and are found at Harrogate, Llandrindod, Aachen, Acqui, Baden (Switzerland), and Uriage.

Iron waters which contain sufficient bicarbonate to be therapeutically active are known as 'pure chalybeate'. The protosulphate and the persulphate and free carbon dioxide are also often present. Trefriw is probably the strongest iron water known. There are pure chalybeate springs at Andeer, Lamalou, Schwalbach, and Spa. *Iron waters*

Many arsenical waters are very feebly mineralized. In the stronger waters of this group arsenic is generally associated with the sulphate or bicarbonate of iron or with the chloride or bicarbonate of sodium. The waters of Mont Dore and La Bourboule are well known examples. *Arsenical waters*

Bromine and iodine waters are muriated waters containing iodides or bromides in minute quantities. The best known are those of Woodhall Spa, Bridge of Allan, Kreuznach, and Salsomaggiore. *Bromine and iodine waters*

4.-SPA TREATMENT

706.] A spa is a health resort which possesses a natural mineral water of proved therapeutic value. Spa treatment not only implies residence at a spa and employment of the natural mineral waters internally, externally, or both, but other factors such as change of air, freedom from worry, and regulation of diet and exercise. In short, spa treatment aims at placing the patient in such an environment that the 'vis medicatrix naturae' can act to the best advantage. *Definition*

Taking these factors in order, it will be seen that spa treatment has well defined features, which may be outlined as follows: (i) Residence at the spa puts the patient into a better state of mind for responding to the therapeutic influences brought to bear on him or her. (ii) The drinking of water, if it has an aperient action, secures increased elimination through the bowel, or, if it has a diuretic effect, through the kidneys. (iii) The external use of water in the form of baths and the administration of massage douches and other physical methods of treatment bring about improvement in the circulation of the blood and lymph. (iv) The relative purity of the air has a good effect on the organism generally. (v) To patients giving up the whole of their time to treatment, very precise instructions can be given about the amounts of exercise, rest, and sleep that should be taken.

The great majority of people who frequent spas are either of middle age or beyond. The fact that spa treatment is needed at all is evidence that their recuperative powers are deficient. A bath can, to some extent, temporarily reproduce the effect of a climate. In this sense the relaxing or bracing effect of a bath can be modified by the atmospheric conditions under which it is taken. A greater reaction would be expected *Precautions*

from stimulating baths in a bracing air than from similar measures in a relaxing atmosphere. To take a concrete example, douche massage at one or two thousand feet elevation has vastly different effects from the same bath at sea-level. It is clear therefore that over-indulgence in baths may cause a certain amount of exhaustion, which the patient rightly considers is due to 'the treatment taking too much out of him'.

After-cures

With these facts in mind it is important to secure a few days' rest before resuming everyday life. It matters very little where this 'after-cure' is carried out. Most patients prefer a change from an inland spa to the sea or from a high to a low level.

Diet at the spas

Most of the spa hotels cater for the dietetic requirements of their patrons. No health resort has any special dietary. The choice of food and the arrangements of meals depend not only on the nature of the patient's illness but also on the preferences of the practitioner in charge of the case.

5.—CLASSIFICATION OF SPAS

Method of classification

707.] In this section the individual spas are briefly described and classified in relation to those conditions which are usually regarded as being suitable for spa treatment.

(1)—Circulatory Disorders

(a) *Indications*

Organic heart disease should not be treated at a spa. Suitable conditions are: myocardial debility due to overwork, 'nervous' hearts with simple tachycardia, disordered action of the heart with effort syndrome, paroxysmal tachycardia when caused by intestinal toxæmia. Arterial hypertension can be well treated at a spa, but great care should be taken in prescribing spa treatment for patients with arteriosclerosis.

Carbon dioxide baths

The claims of various spas for the successful treatment of cardiac disorders are usually based upon their possession of a water charged with carbon dioxide in sufficient quantity to render it effervescing. There are no such waters in the British Isles. When the patient is in the bath the skin rapidly reddens and the contrast between the immersed and non-immersed parts is very striking. It is very doubtful if any of the gas penetrates the horny layer of the skin. There is, however, an increase in the expiration of carbon dioxide which might be explained by general metabolic stimulation. The main feature is the capillary dilatation, which has the effect of lowering blood-pressure, and, in contrast to what happens with other agents that act on the peripheral circulation, the pulse is slowed. The carbon dioxide bath is the only

physical method of treatment in which the cardiac muscle is 'trained' without at the same time increasing the rate of the beat.

(b) *Suitable Spas*

Bagnolles-de-l'Orne (Northern France) is mainly devoted to the treatment of phlebitis and varicose veins. A hot spring—Grande Source—is used for bathing. *Bagnolles-de-l'Orne*

Bad Nauheim (Germany) is famous for its 'Sprudel', a naturally warm saline water highly impregnated with carbon dioxide. The supply is so abundant that upwards of 6,000 baths per day can be provided. They are graded according to the indications of each patient. *Bad Nauheim*

Oeynhausen (Germany) has four muriated springs richly charged with carbon dioxide. Baths are given at varying temperatures and strengths of saline and gas. *Oeynhausen*

Royat (France) has specialized since the beginning of the century in the treatment of arterial hypertension, especially when associated with mental stress and worry. The baths are supplied by four warm springs with a high content of carbon dioxide. *Royat*

Spa (Belgium). La Source Marie Henriette, a water highly impregnated with carbon dioxide, is used for the effervescent baths. There is also a carbonated iron water which has been in use for centuries in the treatment of anaemia. *Spa*

(2)—Genito-Urinary Disorders (Pelvic Conditions)

(a) *Indications*

Backache in women may be due to many causes—to a congested or a displaced uterus, fatigue, fibrositis of the lumbar muscles, enteroptosis, or a movable kidney. Further, what are called 'bearing down' pains are often combined with backache and may be associated with weakness of the pelvic floor, constipation, and haemorrhoids. When dysmenorrhoea is due to chronic congestive conditions in the pelvis or sub-involution of the uterus, a course of thermal baths with hot packs of mud, peat, or 'mother-lye', combined with a mild aperient water internally will nearly always bring about a marked improvement. *Backache*
Dysmenorrhoea

(b) *Suitable Spas*

Brides-les-Bains and Salins-Moutiers (Savoy, France) are only a few kilometres apart and are really one spa. The water at Brides is warm, muriated, and sulphated, and has a mild aperient effect; the water at Salins is effervescent and used for bathing. *Brides-les-Bains and Salins-Moutiers*

Kreuznach (Germany) possesses very strong brine springs utilized solely for bathing. A strong solution of the salts—'Mutterlauge'—is added to the water. *Kreuznach*

- Luxeuil-les-Bains* Luxeuil-les-Bains (France) is primarily a bathing spa. Immersion baths are combined with vaginal irrigation. In this way the water at almost no pressure at all comes in direct contact with the cervix.
- Salso-maggiore* Salsomaggiore (Italy) has a cold muriated bromo iodine water which after partial evaporation leaves a liquid known as the 'mother-liquor'. This is added to the baths to increase their strength.
- Bad Schwalbach* Bad Schwalbach (Langen Schwalbach, Germany) is famous for its 'iron mud baths', which are prepared from the ferruginous deposits in the neighbourhood of the springs and have a reputation for bringing about the resolution of old inflammatory lesions.
- Woodhall Spa* Woodhall Spa (Lincolnshire) has water very similar to that of Salsomaggiore. Packs for external application are made up from the 'mother-lye'.

(3)—Genito-Urinary Disorders (Urinary Disorders)

(a) Indications

Spa treatment is contra-indicated in organic disease of the kidney. If renal function is definitely impaired, the additional strain imposed by large draughts of mineral water may have untoward results. But when renal function is more or less normal, a suitable mineral water will flush out the system generally and thus remove the additional waste products liberated by various forms of external treatment.

Nephrolithiasis

The sulphated bicarbonated calcium waters, having a marked diuretic effect, can often dislodge small calculi which can then be passed. No mineral water can ever have the slightest effect on the size of a stone, but it can clear away any debris that has formed round a calculus. Patients often feel more comfortable after drinking such a water. As a pre-operative measure, a course of mineral water, by its flushing action, will be beneficial.

(b) Suitable Spas

- Llandrindod Wells* Llandrindod Wells (Wales). The waters are (i) simple salines, (ii) sulphuretted salines (sulphuretted hydrogen present), and (iii) chalybeate. The sulphurated salines are strongly diuretic, and on these the reputation of Llandrindod as a 'diuretic' spa depends.
- Contrexéville* Contrexéville (France). The 'Pavillon' spring, a sulphated bicarbonated calcium water, is widely known. It is diuretic, laxative, and cholagogue, all watery excretions being much increased. After a course of Contrexéville waters patients with renal calculi say that 'the stone is more bearable'.
- Evian* Evian (Savoy, France). The water is cold, non-gaseous, and only slightly mineralized. Before and after kidney operations Evian water is useful as a flushing and cleansing agent.
- Wildungen* Wildungen (Germany). There are three cold gaseous springs of ex-

tremely low mineralization. The 'Helenenquelle', besides being valuable in renal lithiasis and gout, is extensively ordered in chronic pyelitis to wash away the debris of calculi.

(4)—Disorders of Metabolism and Digestion

(a) Indications

The pathogeny of gout being still incompletely known, spa treatment of this condition is almost entirely empirical. Indeed this treatment, even when confined to water drinking but especially when baths are taken as well, often brings on an attack. By many patients such induced gout is regarded as part of the treatment, after which they are free from gouty manifestations for much longer than they would be otherwise. The spas recommended for gout and its reputed manifestations are mentioned on pages 594, 596, and 597.

Mineral waters cannot cure constipation though many of them relieve the condition greatly owing to their action as cholagogues, thereby increasing the amount of bile which is a natural purgative.

At the beginning of a course of spa treatment a few colonic irrigations by the local mineral water are often useful for removing hardened faeces. Routine colonic lavage, however, has little to recommend it and in many cases may aggravate the condition it is supposed to cure.

Patients with chronic colitis often do well at a spa where colonic irrigation with a mild mineral water can be carried out.

Old-standing ulcers which have been associated with bacillary dysentery derive benefit from spa treatment. Hydrotherapy is applied locally as colonic lavage, and generally also as water-drinking and bathing.

In obesity cure at a suitable spa is helpful. Those who benefit most are middle-aged, under-exercised, over-fed, self-indulgent persons who make a yearly pilgrimage for the remission of their dietetic sins; and among such persons the popularity of some of these spas, particularly those possessing waters with aperient properties, is not unnaturally enhanced by the fact that the limitations of diet are not excessive.

Hepatic disease if organic will not derive any benefit from spa treatment. It is mainly in the early stages before permanent tissue changes have taken place that most good can be done. The waters of Harrogate and Karlsbad have almost a specific action as hepatic stimulants and for cholelithiasis.

In disorders of the stomach and intestine, exemplified by irritable and chronic catarrhal conditions in persons of plethoric habit, in whom gastric secretion is excessive and over-acid, the sulphated alkaline waters (Karlsbad and Marienbad) may be prescribed with benefit. The muriated alkaline waters (Vichy) are more likely to be beneficial in cases in which secretion is deficient and sub-acid.

Chlorosis, now extremely rare, is very amenable to treatment at a chalybeate spa.

*Gout**Constipation**Chronic colitis**Tropical diseases**Obesity**Disorders of the liver and cholelithiasis**Gastro-intestinal disorders**Chlorosis*

(b) Suitable Spas

- Bath** Bath is unique among the British spas in the possession of natural hot-water springs (120° F.). The supply is abundant—half a million gallons per day. The water is feebly mineralized. Taken internally it acts as a diuretic and is much used in the treatment of gouty conditions. Perhaps the most characteristic treatment in Bath is the provision of deep baths each containing several hundred gallons of natural hot mineral water free from admixture of any kind. An 'under-current douche' of hotter water directed to the affected parts is also employed.
- Harrogate** Harrogate is celebrated for the number and variety of its waters, which can be divided into two groups: (i) a sulphur group (containing sulphur as sulphide) and (ii) an iron group. Sulphides and common salt characterize the series known as the saline sulphur group (Old Well, Strong Montpelier Sulphur, Mild Sulphur, No. 36). In the absence of such salts the small class of alkaline sulphur waters results
- Sulphur waters** (Beckwith, Starbeck, and Harlow Car sulphur waters). The iron waters are divided into a saline iron group (Kissingen Well) and pure chalybeate (Tewitt Well).
- Iron waters**
- Indications** The indications are as follows: (i) metabolic disorders underlying the gouty state, obesity, functional liver derangements with threatening cirrhosis, cholelithiasis and cholecystitis, as well as certain skin affections believed to be associated with a gouty diathesis; (ii) synovitis, fibrositis, sciatica, and brachial neuritis when caused by defective elimination. Patients suffering from the effects of long residence in the tropics can be sent to Harrogate with advantage.
- Royal Leamington Spa** Royal Leamington Spa has waters belonging to the muriated sulphated group, which are mildly aperient and diuretic. Externally they are employed as immersion baths and massage douches. When diluted they are used for colonic irrigation. The indications are goutiness, obesity, and other conditions due to faulty metabolism. Latterly the immersion baths have been supplied in an effervescent form for the treatment of cardiovascular conditions. The flatness of the surrounding country is well adapted to cardiac cases.
- Indications**
- Trefriw Wells** Trefriw Wells has springs containing the most concentrated iron water known. The dose instead of being one or two tumblers is only a tablespoonful. The main indication is anaemia, either alone or in association with other conditions. The waters are supplied for home consumption.
- Indications**
- Baden** Baden (Switzerland) possesses hot saline sulphur springs with a fairly high calcium content. Taken internally the waters are aperient and useful in the treatment of metabolic disorders, disturbances of nutrition, obesity, and irregular gout.
- Franzensbad** Franzensbad (Czechoslovakia) possesses sulphated alkaline waters containing various amounts of iron, used in the treatment of anaemia and debility. The peat obtained locally is used for baths.
- Karlsbad** Karlsbad (Czechoslovakia). The chief ingredients in the waters are sodium, potassium, sulphates, chlorides, and carbonates. The main

difference in the springs lies in their temperature; the famous 'Sprudel' is the hottest. The waters are powerful cholagogues and much pre-
Indications
 scribed in cases of liver disorders and chronic cholelithiasis. Irregular
 gout when manifested by gastric catarrh and complicated by glycosuria
 is often benefited by a 'cure' here.

Marienbad (Czechoslovakia). The waters here are all cold and belong
 to the sulphated alkaline class. They are mainly used in the treatment of
 the full-blooded, stout individual who leads a sedentary life and habitu-
 ally overeats. *Marienbad*

Vichy (France). The chief constituents of the water are sodium and
 bicarbonate ions with free carbon dioxide. The muriated alkaline
 springs are both thermal and cold. The dyspeptics who benefit from
 treatment are the pale, thin, and restless persons whose tongue becomes
 furred with the slightest dietary indiscretion, and those whose condition
 is associated with enteroptosis and nervous disorders due to sympathetic
 imbalance. The two principal indications for the Vichy treatment of
 hepatic cases are cholelithiasis and congested states. *Vichy*
Indications

Vittel (France). There are two slightly mineralized cold springs with
 mainly laxative and diuretic effects; they are used in the treatment of
 gout and goutiness, including not only acute and chronic forms but
 those conditions included under the term 'irregular' gout, such as
 migraine, neuralgias, phlebitis and peri-phlebitis, and pharyngeal and
 bronchial affections. Vittel is well equipped with all the various forms
 of physiotherapy, including a 'training' cure for bringing down the
 weight of obese patients. *Vittel*
Indications

(5)—Disorders of the Nervous System

(a) *Indications*

Harm may be done by sending patients who need psychological
 treatment on long journeys by land or sea (see CLIMATE IN THE TREAT-
 MENT OF DISEASE, Vol. III, p. 240), but hydrotherapy occupies a very
 definite place in the treatment of psychasthenia, and most modern
 mental hospitals are equipped with various kinds of douches and
 immersion baths.

Immersion in a bath at a neutral temperature of 93° F. (sometimes
 called the point of thermal indifference) cuts out many peripheral
 stimuli to which an excited nervous person may respond too readily.
 Prolonged baths or douches of this kind are very valuable in the
 treatment of excitement and restlessness associated with psychotic
 states. The full wet pack (see p. 587) is employed with much the same
 object, and it is to be regretted that more use is not made of this. It
 is most soothing and enables patients to obtain sleep without the use
 of drugs.

In organic disease of the central nervous system, hydrotherapy
 cannot be expected to exert any favourable influence on the actual
 lesion. On the other hand, re-educative movements in the symptomatic
 treatment of paralysis can be carried out more effectually in a pool
Organic disease

bath than anywhere else. Pool baths equipped with the under-water douche can, as a rule, only be obtained at certain spas. In the case of an upper neurone paralysis, the hypertonus, spasm, and contractures are lessened by the heat of the water, and the weight of the limb is rendered negligible by the buoyancy of the medium.

(b) *Suitable Spas*

- Badenweiler* At Badenweiler (Germany) whey, milk, and grape cures can be carried out. The climate suits psychasthenics and overworked delicate individuals.
- Bex-les-Bains* Bex-les-Bains (Switzerland) has a very even temperature and is situated amidst most attractive surroundings. For cases of neuralgia and other painful conditions brine baths are available.
- Badgastein* Badgastein (Austria) has thermal springs of low mineralization: temperature 117° F. The hot baths have an established reputation in the treatment of various nervous affections. They are also indicated in the asthenia of old people. Some symptomatic relief is claimed for their use in Parkinson's disease.
- Lamalou* Lamalou (France) is near the Cévennes, and its climate is remarkable for the purity of the air and the mildness of the temperature. The spa is fully equipped with the usual hydrotherapeutic apparatus.
- Leukerbad* Leukerbad (Loèche-les-Bains, Switzerland) provides a combination of mountain air and a thermal water which has been found of value in the treatment of various functional nervous disorders.

(6)—Respiratory Disorders

(a) *Indications*

Affections of the respiratory system such as pharyngitis, laryngitis, tracheo-bronchitis, and bronchitis (chronic), when associated with an underlying gouty diathesis, usually do well with spa treatment. At most of the spas where respiratory affections are treated, special inhalation rooms are provided. In these rooms the local mineral water is pulverized and added to the air which the patients are breathing. Besides the rooms, there are douches, sprays, and gargles for more localized treatment.

Compression chamber At many of the spas on the continent of Europe the 'compression chamber' is available. This increases the amount of oxygen present, and in consequence breathing is much easier.

Asthma If asthma can be traced to gastro-intestinal disorder, or to faulty metabolism such as gout, spa treatment may do good, but to label certain spas as 'asthma spas' to which anyone suffering with spasmodic attacks of dyspnoea may be sent without any regard to the cause is manifestly unscientific.

(b) *Suitable Spas*

Allevard Allevard (France) provides hot inhalation rooms for the diffusion of sulphur water highly charged with sulphuretted hydrogen.

La Bourboule (France) possesses hyperthermal water containing a minute quantity of arsenic. The water is applied in the form of local douches and gargles, and the gaseous emanation is used in the treatment of spasmodic and recurrent congestive conditions of the nasal cavities. There are also vapour and 'fog' rooms. Children do very well here.

La Bourboule

Bad Ems (Germany) has a large inhalatorium in which seven hundred patients can be treated at one time. The water belongs to the muriated alkaline group. The temperature of the springs ranges from 85° to 115° F.

Bad Ems

Mont Dore (France) is famous for its '*salle d'aspiration*'. Large halls are kept filled with a warm fog obtained by passing steam through the mineral water and then atomizing some of the latter into the fog thus produced. This treatment, by rendering the expectoration more fluid, is sedative in effect. The linings of the respiratory passages absorb some of the mineral water. The gaseous emanation is applied locally by means of a wooden tube through which the gas is insufflated. Nasal insufflation by this method is constrictive, decongestive, and drying.

Mont Dore

Bad Reichenhall (Germany) has a very strong brine, the only mineral water. It is employed for inhalation therapy, either at the 'graduation plant' or in the chambers where the water is pulverized. The former—'graduation plant'—is situated in a large building with a wooden framework supporting walls of whitethorn over which the brine trickles, dripping from twig to twig and thus charging the air heavily with salt solution. The patients stand, sit, or walk about in the building and breathe the saturated air. Several hundred patients can take the treatment at the same time. This treatment is valuable in catarrhal affections of the respiratory passages, rhinitis, pharyngitis, and chronic dry laryngitis. Pneumatic chambers giving an additional pressure of half an atmosphere are also available; in these the patient remains for an hour or more.

Bad Reichenhall

(7)—Chronic Rheumatism

(a) *Indications*

Perhaps the most important measures in the early treatment of rheumatoid arthritis are attention to general health and the performance of breathing exercises in the recumbent posture. At spas these measures may be supplemented by the ingestion each day of mineral water, which has an excellent psychological effect if no other. It would be an advantage if, at some of the more bracing spas, the routine adopted were based on a realization of the fact, often overlooked, that the treatment of early rheumatoid arthritis should be very similar to that of early pulmonary tuberculosis.

Rheumatoid arthritis

In osteoarthritis spa treatment should be directed towards the relief of any faulty metabolic process that may be present, the outstanding need perhaps being to reduce the calorific value of the diet to reason-

Osteoarthritis

able limits. Nearly all osteoarthritic persons frequenting spas habitually eat too much. Careful regulation of the diet, more especially as regards the quantity, will spare the patient any unnecessary metabolic burdens.

Any physical measures undertaken should be directed to maintain the function of the joints. For this reason spas with pool baths should be recommended for such cases.

*Climacteric
arthritis*

In menopausal arthritis, which is often associated with an increase in the bodily weight, the various physical methods of treatment available at the spas are of great value.

(b) Suitable Spas

Buxton

Buxton, about 1,000 feet above the sea-level, is the highest spa in England. The air is very bracing. The waters are tepid (82° F.) and of feeble mineralization. They contain a comparatively large amount of nitrogen which, although inert, carries the radium emanation to which therapeutic properties are ascribed. Taken internally the waters are diuretic. Externally they are employed in pool baths and massage douches. Buxton possesses a very complete physiotherapeutic installation.

Droitwich

Droitwich. The brine baths of this spa produce their effect as follows: (i) The natural buoyancy of the water enables the patients to move their stiffened limbs through ranges otherwise impossible, the supporting action of brine being much greater than that of ordinary water. (ii) The surface action or stimulation of the skin promotes free and copious sweating and increases the circulation in the superficial capillaries and lymphatics. (iii) The hot baths have the effects described on page 577.

Acqui

Acqui (Northern Italy). Treatment here is chiefly confined to the application of fango packs. Fango is an organic mud obtained from deposits round the thermal springs.

Aachen

Aachen (Aix-la-Chapelle, Germany). The springs belong to the thermal alkaline muriated sulphur group. The large pool bath is the outstanding feature of the treatment here. Hotels and bathing establishments in many instances are combined under one roof.

Aix-les-Bains

Aix-les-Bains (France) is almost entirely a bathing spa. The Aix massage douche is given with water obtained from two hot sulphur springs. The water holds in suspension whitish flakes of oily organic nature which make it a very suitable medium for massage.

Baden-Baden

Baden-Baden (Germany) has about twenty simple thermal muriated springs and a particularly fine bathing establishment.

Buda Pest

Buda Pest (Hungary) possesses an almost unlimited supply of simple thermal and thermal sulphur water, mostly used for bathing. There are also some thermal mud pools.

Dax

Dax (France). The mud employed in the baths is formed by the action of the thermal water on the banks of mud left by the periodical overflowing of the river.

Pistany

Pistany (Czechoslovakia). The thermal springs arise from a depth of several hundred feet from a large enclosed basin filled with sulphur

water and muddy deposit. The thermal sulphur water is used in ordinary reclining baths and the mud in the form of a 'mud pool' bath or as packs for local application.

Rheinfelden (Switzerland). The brine found here is practically a *Rheinfelden* saturated solution of salt. It is used for baths and douches.

Wiesbaden (Germany) possesses thermal muriated waters with temperatures ranging from 100° to 156° F. *Wiesbaden*

(8)—Skin Diseases

(a) Indications

Spa treatment is only applicable in the more chronic stages of skin disorders. Natural mineral waters are employed internally, externally, or both.

Their internal use is chiefly in conditions associated with faulty *Internal use* metabolism or defective general health. As examples of these may be mentioned the eczema found in gout and the pruritus of glycosuria. In such instances a water of low mineralization appears to be most suitable.

The internal employment of sulphur water in gouty skin eruptions *Sulphur water* is very apt to bring on an acute attack. This is probably accounted for by the high saline content of most of these waters. On the other hand, in seborrhoea associated with sedentary habits and close confinement in unhealthy buildings, a course of sulphur water, by its action on the hepatic function and the bowel, often brings about well marked improvement in the skin.

Of the three types of sulphur water mentioned on page 588, that *Baths* which contains the most sulphuretted hydrogen is usually employed for baths. The 'muriated' sulphuretted water, owing to its greater proportion of salt, is apt to be too irritating.

No patient should ever be sent to a spa for treatment until all aetiological possibilities have been thoroughly explored. Diagnostic pitfalls *Selection of caves* are all too numerous.

(b) Suitable Spas

Strathpeffer. The sulphuretted waters (cold) are noted for their high *Strathpeffer* content of sulphuretted hydrogen. They are diuretic and mildly purgative. Employed as full immersion baths the water is very soothing in cases of irritable skin affections.

Barèges (France). The thermal waters are used for baths. Dry scaly *Barèges* eczema is said to do extremely well here.

Saint-Gervais (France). The waters contain among other constituents *Saint-Gervais* lithium and silicates. The silicates make the water extremely soft to the touch. The baths are chiefly used in pruritus, prurigo, lichen planus in its eruptive stage, and other irritable conditions.

Saint-Honoré-les-Bains (France) provides tepid waters of low mineral- *Saint-Honoré-les-Bains* ization containing sodium bicarbonate and a minute trace of arsenic;

it is looked upon rather as a children's spa. Eczema and impetigo are well treated here.

Lenk Lenk (Switzerland). The sulphur water is used in eczema and furunculosis.

La Roche-Posay La Roche-Posay (France). When used in a bath, the water deposits on the skin a whitish film which acts as a soothing dressing and relieves irritation. Taken internally the water is diuretic.

Schinznach Schinznach (Switzerland). The hot sulphur springs yield nearly 400,000 gallons per day. The baths are much used in psoriasis, ichthyosis, prurigo, acne, and staphylococcal infections of the skin. The best results are seen in dry harsh skins with scaldness and thickened epidermis.

Uriage Uriage (France) has a sulphur water that is much used in the treatment of chronic eczema, lichen planus, prurigo, and skin conditions due to lowering of the general health.

I have to express indebtedness to my publishers, Messrs. Edward Arnold and Co., for permission to draw extensively upon my work, Hydrotherapy and Climatothrapy, mentioned in the bibliography below.

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NOTE

An exhaustive analytical index to the *British Encyclopaedia of Medical Practice* will be published on completion of the work. In the meantime, each individual title is separately indexed in the volume to which it belongs, and there are additional references and cross-references to assist the reader in finding whatever information he may require as easily and quickly as possible.

The entries in heavy black type (e.g. **Gonorrhoea**) indicate the individual titles; those in large capitals (e.g. **ABDOMINAL PAIN**) indicate the additional references and cross-references.

THE PUBLISHERS

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